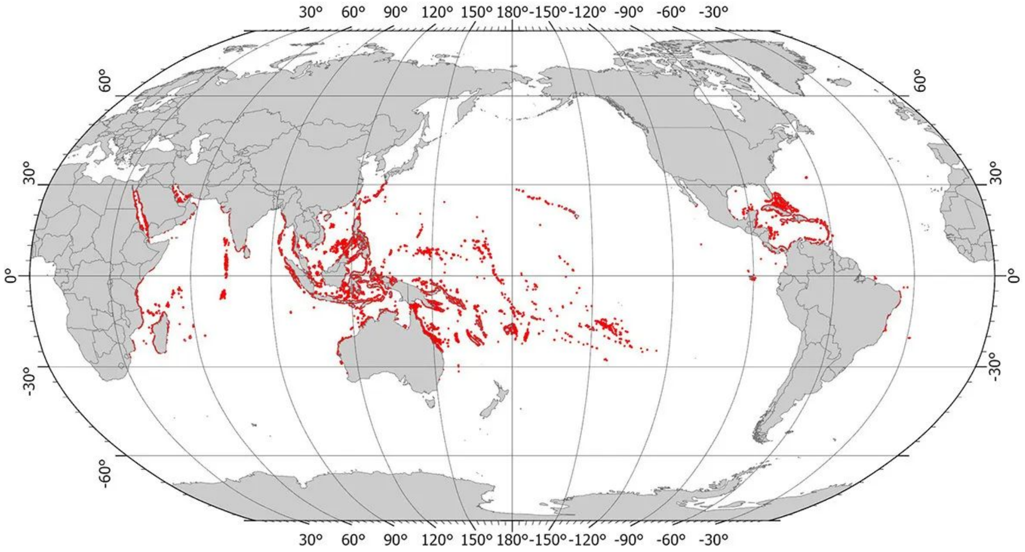
P5

Acropora valida

Gees Brouwer * 31 okt. 2024



Background & Incentive > Spoiler > Structure of the next ½

Coral Reefs

< 0.1% of the ocean floor,

BUT...

support 25% of marine life,

protect coastlines,

are really beautiful!

Coral

colonies of small animals (polyps)

that are building structures

of many different shapes

Threats

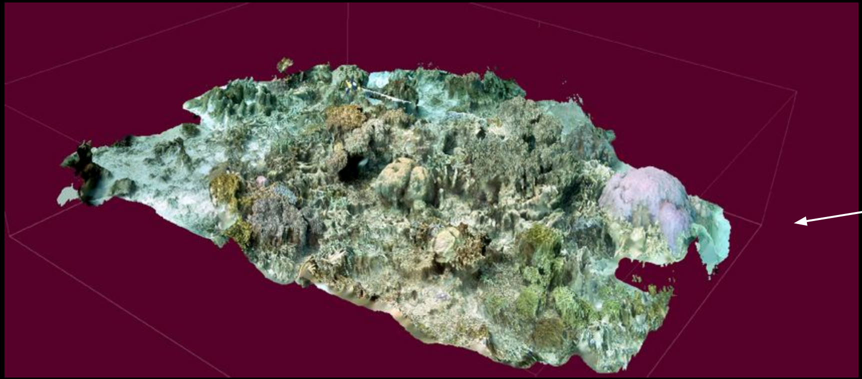

[4]


+ 1.5°C
70 to 90%
of coral reefs
will vanish
+ 2°C
99%
of coral reefs
will vanish
[5]

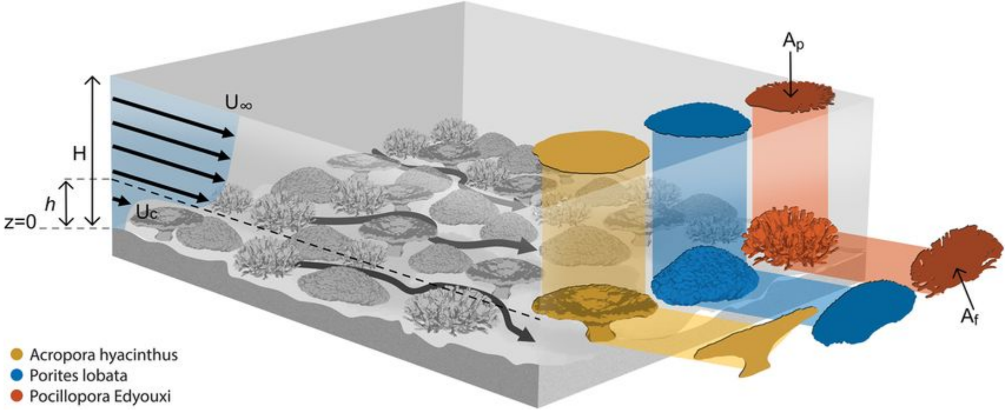
?

Technological Advancements

Computer Vision



3D Scanning



H
U_∞
h
z=0
U_c
A_p
A_f
Acropora hyacinthus
Porites lobata
Pocillopora Edyouxi

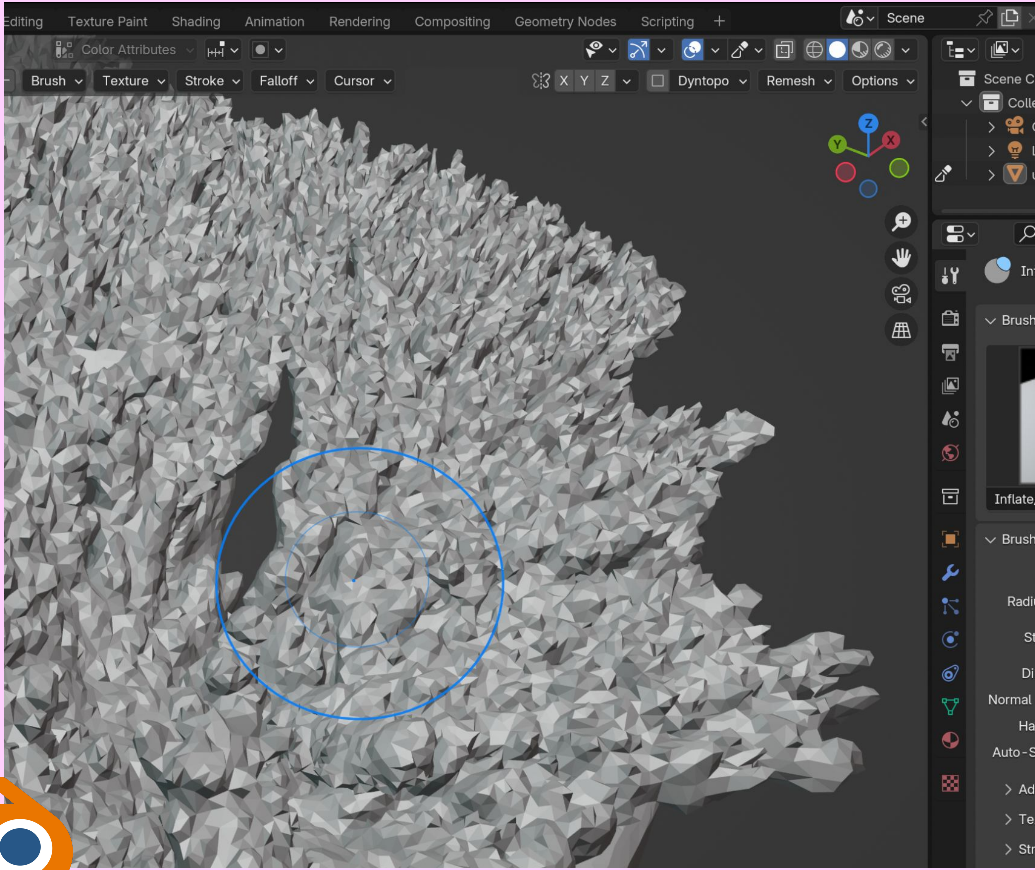
[7]

3D Models

Photogrammetry

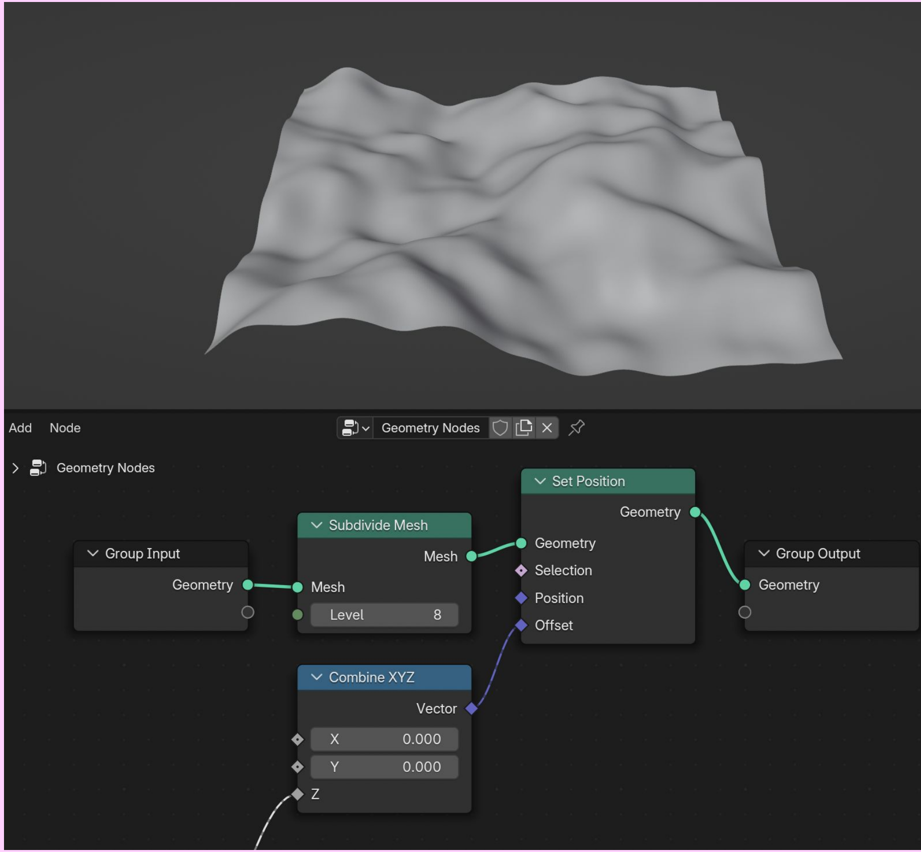
If you have sufficient

Time & Expertise...



If you have sufficient

~~Time~~ & Expertise...



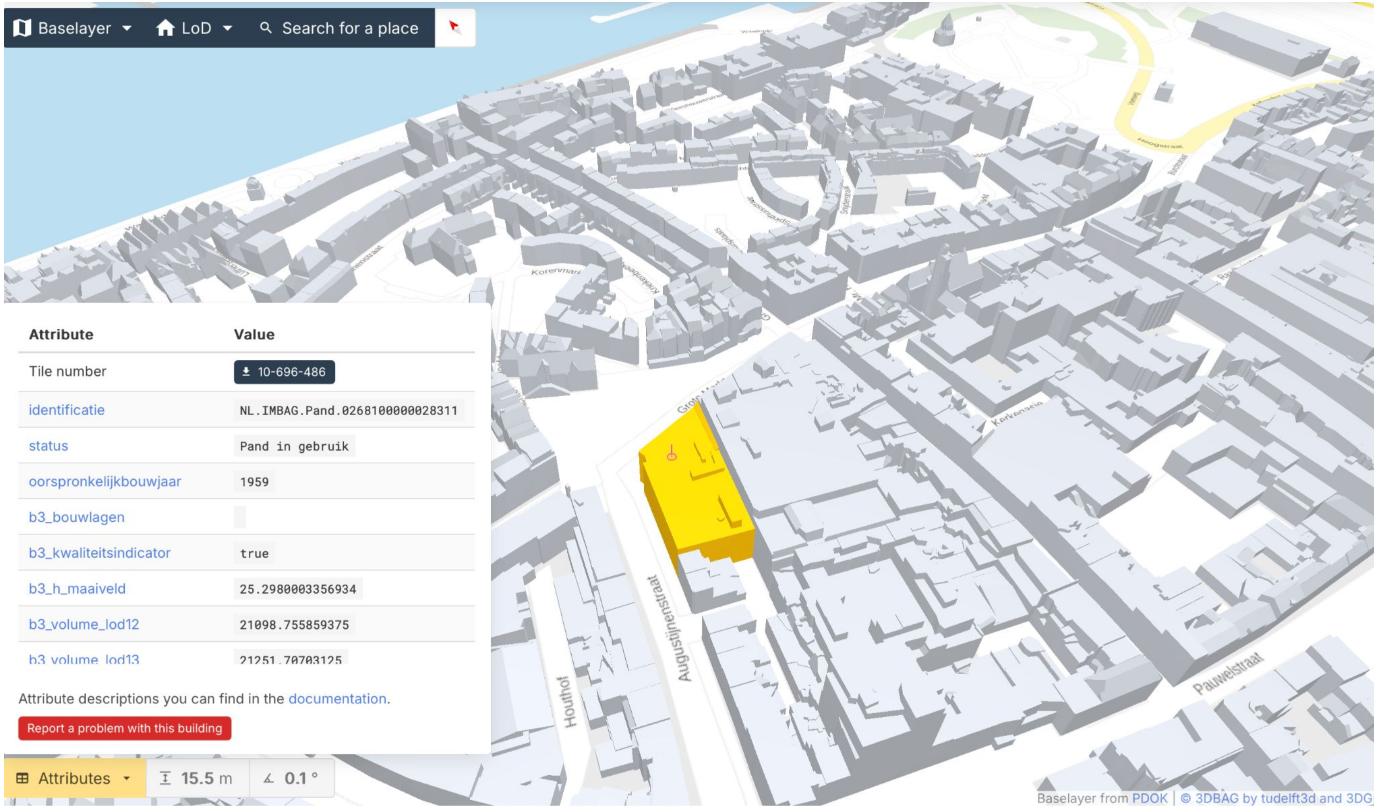
?

Geomatics – for the Built Environment

The science of Geomatics concerns the acquisition, modelling, analysis, management and visualisation of geographic data with the aim of gaining knowledge and a better understanding of the built and natural environments. The programme at TU Delft differs from other Geomatics programmes in its broad and interdisciplinary nature and technical depth as well as its close connection to the Faculty of Architecture and the Built Environment. With increasing amounts of geographic data being collected and growing insight into how value can be added through analysis of this data, the demand for experts in the field is rapidly growing. Hence Geomatics graduates easily find jobs in companies, universities and governmental institutes locally and abroad.

At Geomatics we host a high percentage of international students with very diverse academic backgrounds. The fact that the programme is relatively small contributes to a communal group feeling among the students and a close connection to the lecturers. Additionally, the student association GEOS regularly organises career-related and social activities such as the annual trip to the INTERGEO conference in Germany.

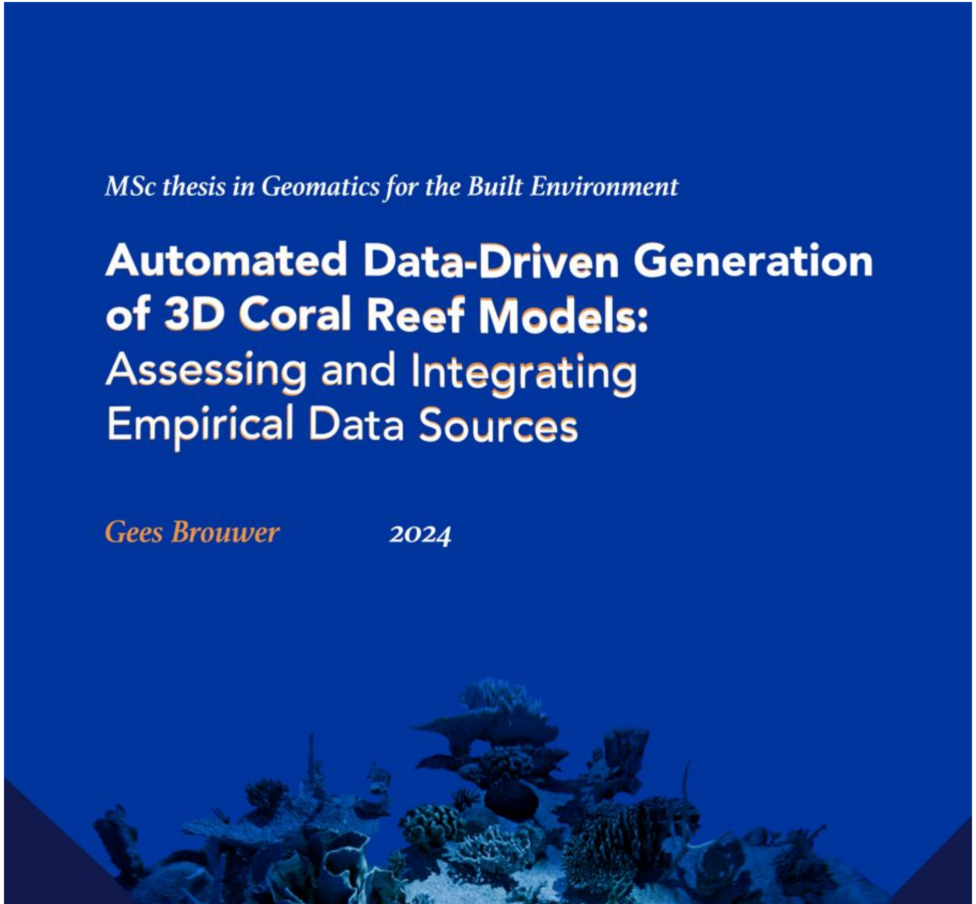
What will you learn


Baselayer
LoD
Search for a place
Attribute
Value
Tile number
10-696-486
identificatie
NL.IMBAG.Pand.0268100000028311
status
Pand in gebruik
oorspronkelijkbouwjaar
1959
b3_bouwlagen
b3_kwaliteitsindicator
true
b3_h_maaiveld
25.2980003356934
b3_volume_lod12
21098.755859375
Attribute descriptions you can find in the documentation.
Report a problem with this building
Attributes
15.5 m
0.1 °
Augustijnenstraat
Houthof
Pauwelstraat
Baselayer from PDOK | © 3DBAG by tudelft3d and 3DG

1 INTRODUCTION

1.1 Background

Coral reefs are among the most diverse and ecologically significant ecosystems on Earth (Fisher et al., 2015), often referred to as the "cities of the sea" (Wicks 2016) due to their complex structures and the vast number of species they support. Despite covering less than 0.1% of the ocean floor, coral reefs provide habitat for approximately 25% of all marine species (Spalding et al., 2001). Corals, which are actually colonies of small animals called polyps, form the foundation of these ecosystems by secreting calcium carbonate to create a hard skeleton. Different coral species grow into many different shapes—such as branching or massive growth forms, as shown in **Figure 1.1**—each contributing to the overall structure of the reef. This diversity in shape and structure adds to the habitat complexity of the reef and helps support a wide range of marine life.



Data-driven perspective

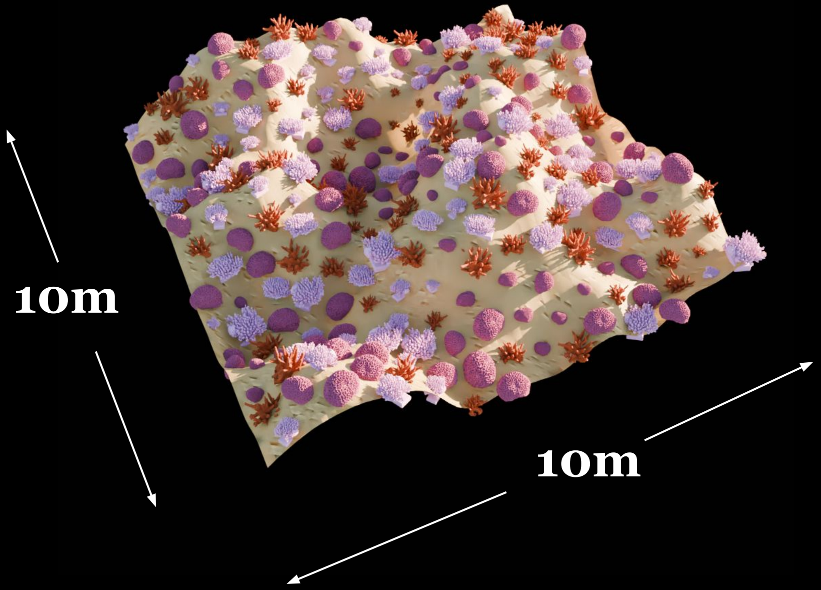
- Systematic, quantitative
- Spatial patterns/relationships?

Dynamic and adaptable

- Rapidly growing data!

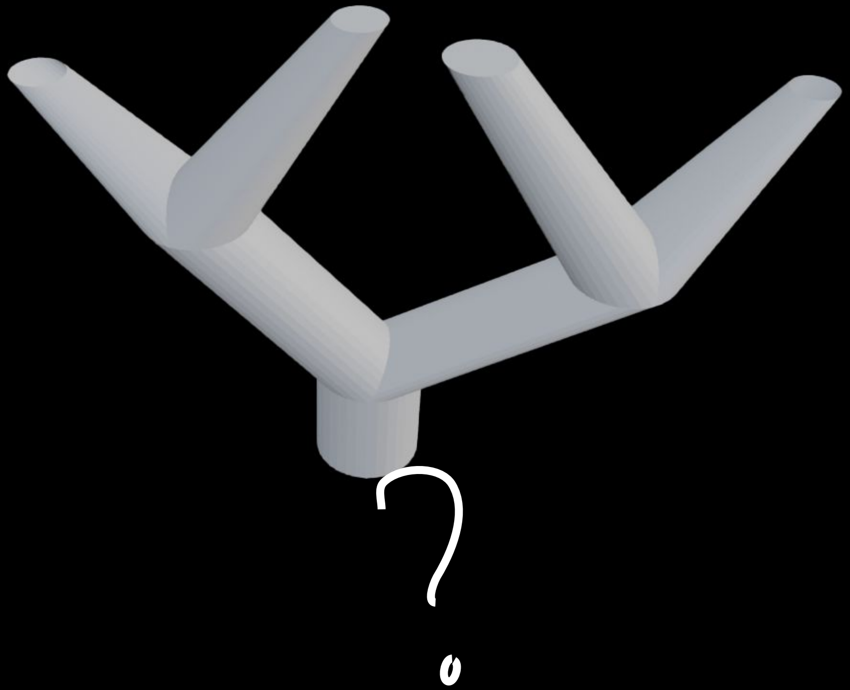
Integrative

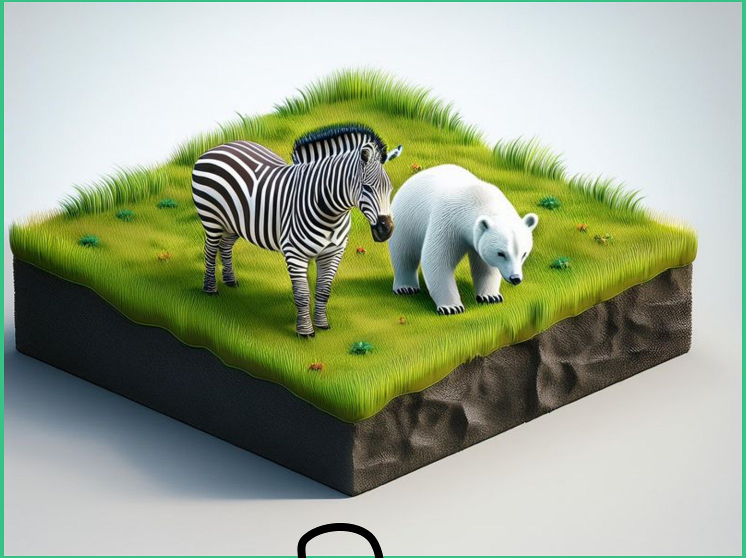
- Fusion of data from multiple origins



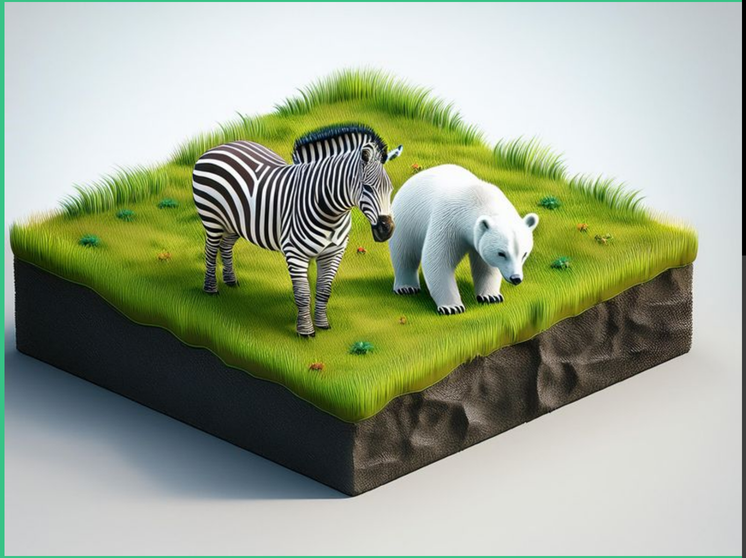
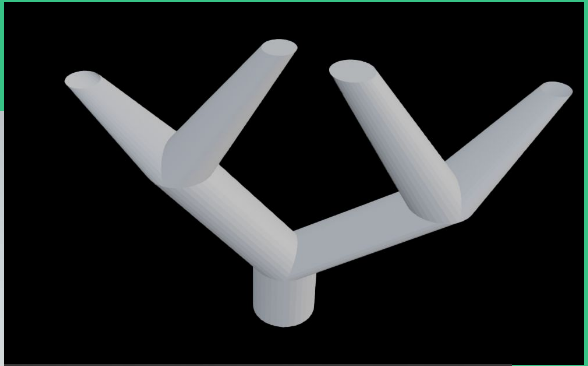
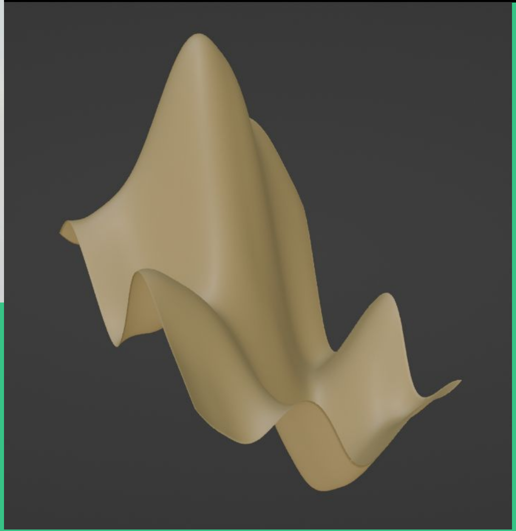
- Pipeline for automated modelling
- Extract information from data sources
- *"Ecologically plausible"* models

Ecologically plausible? ➢

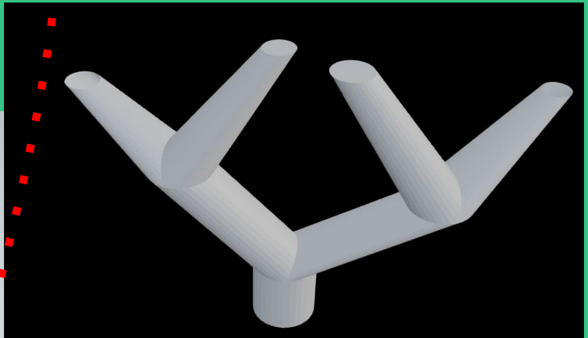




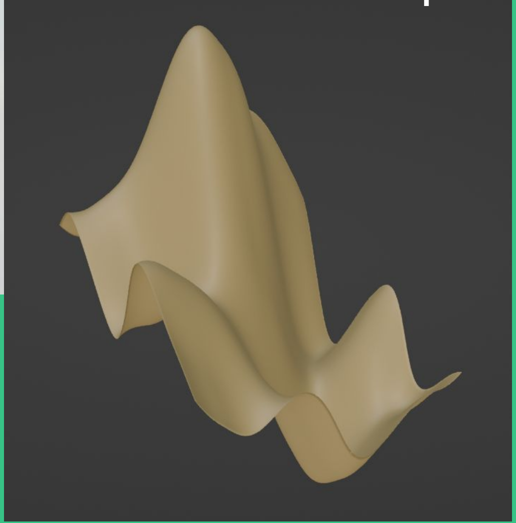
?

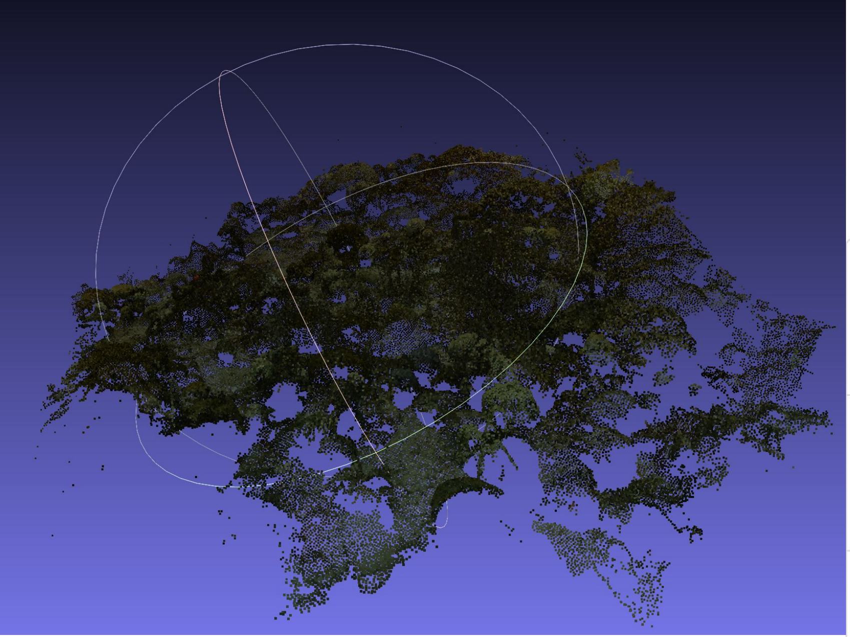
Deeper foundational aspects

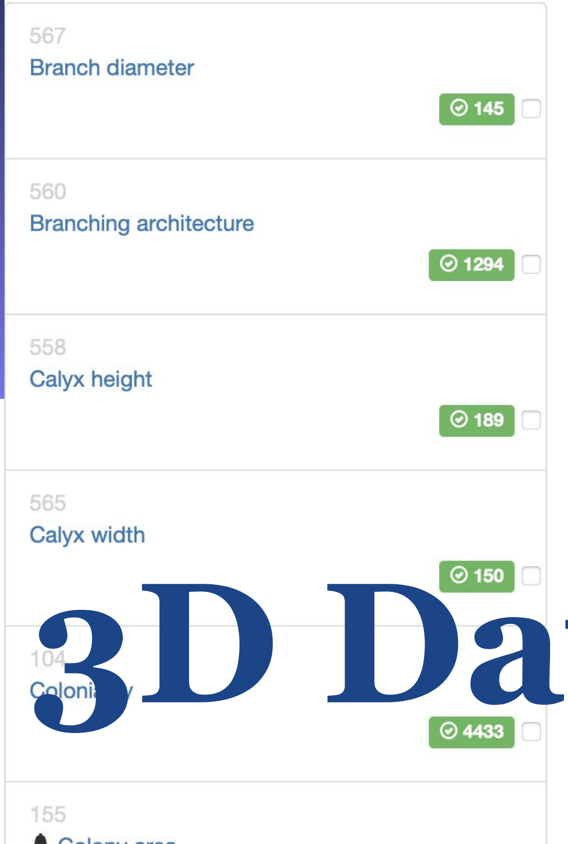


Visible structural aspects

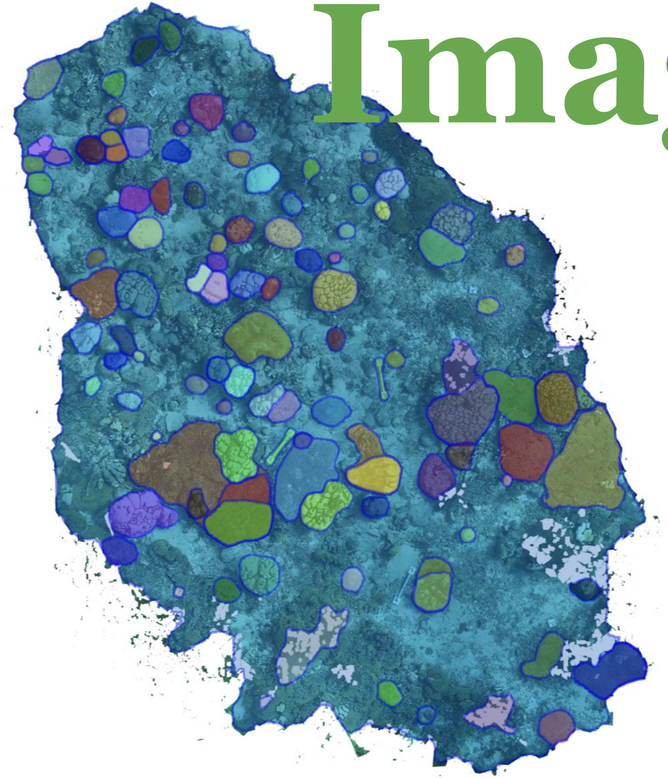


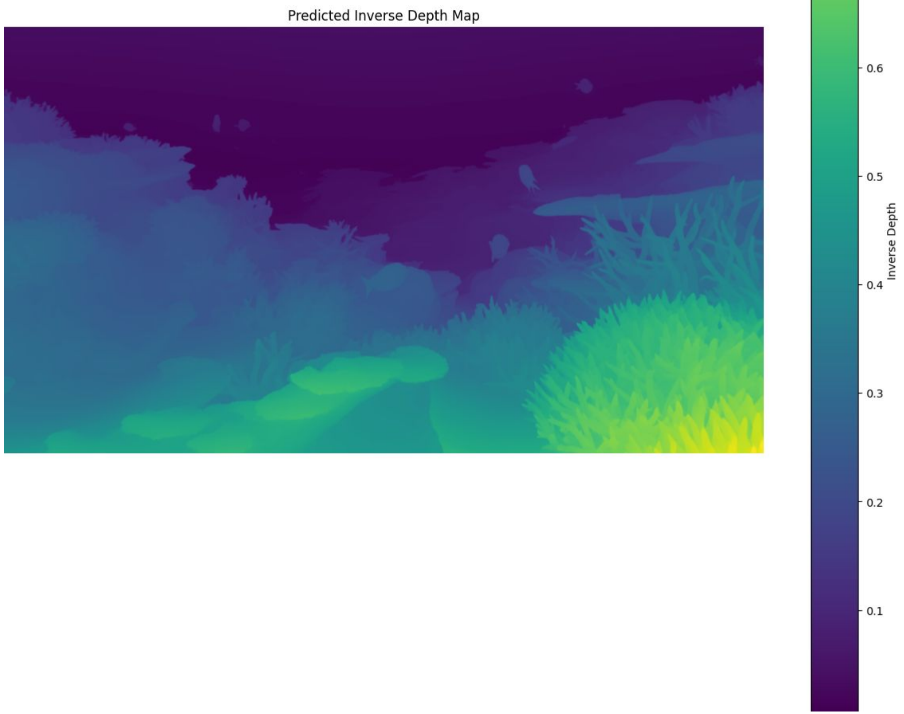
3D Data



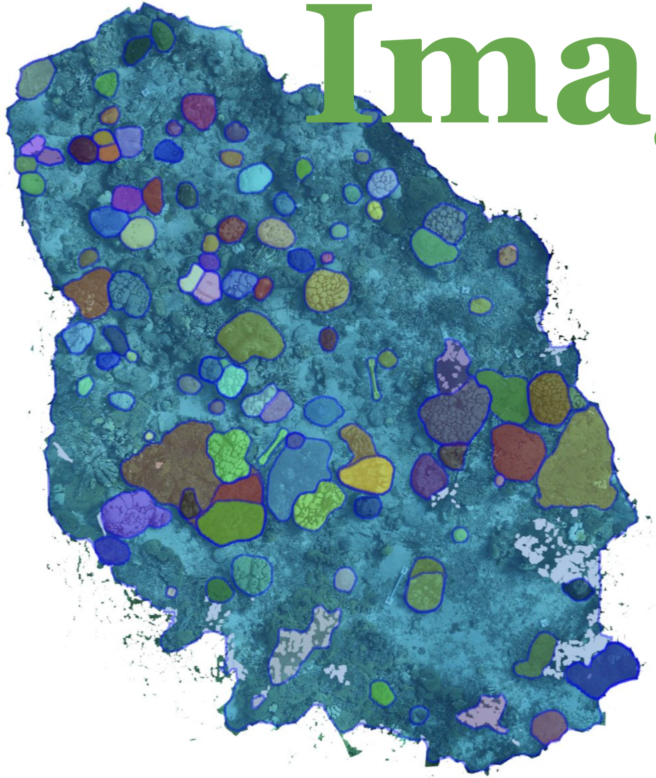

567
Branch diameter
145
560
Branching architecture
1294
558
Calyx height
189
565
Calyx width
150
104
4433
155

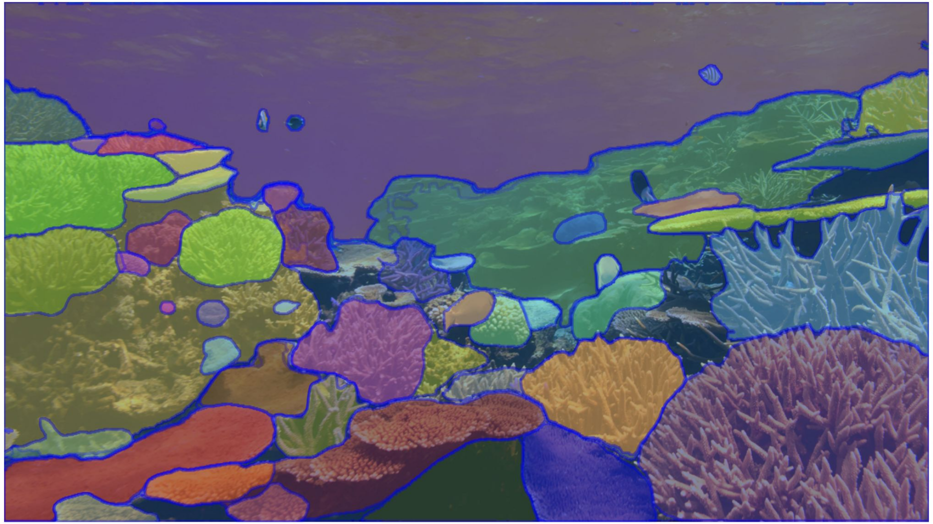
Images



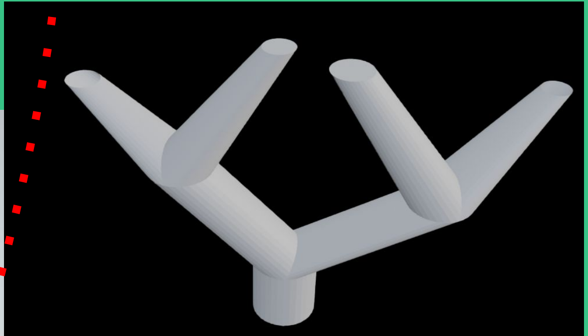

Predicted Inverse Depth Map
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Inverse Depth

Images

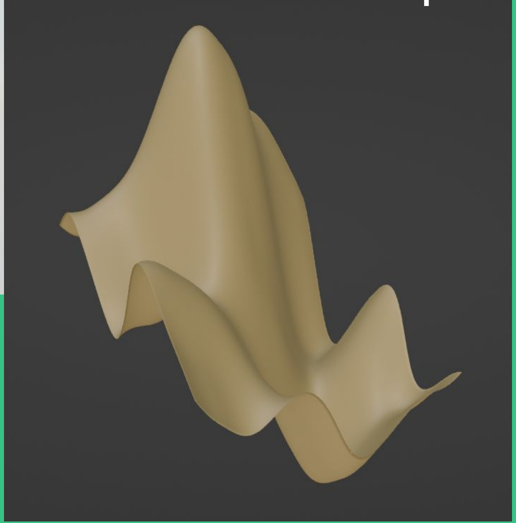


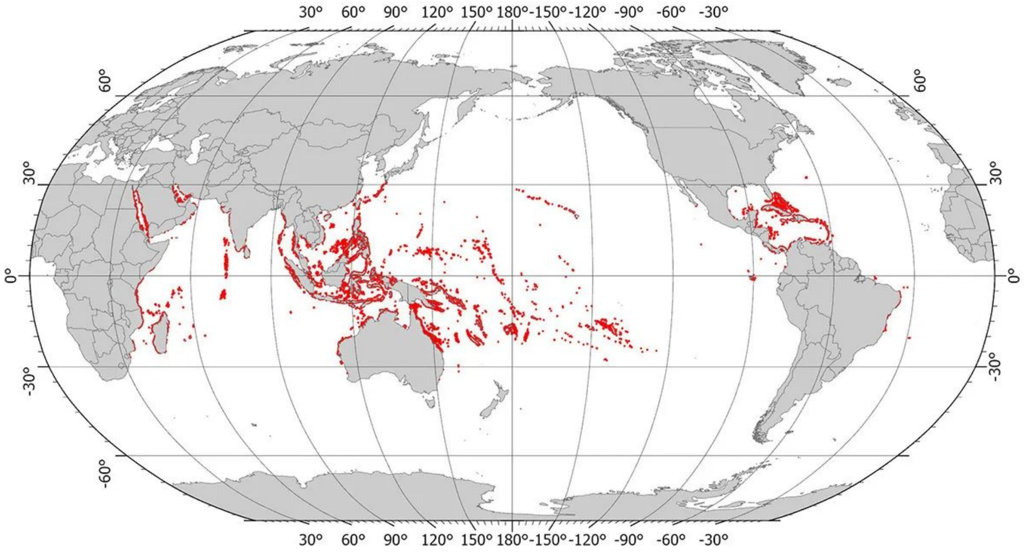


Deeper foundational aspects

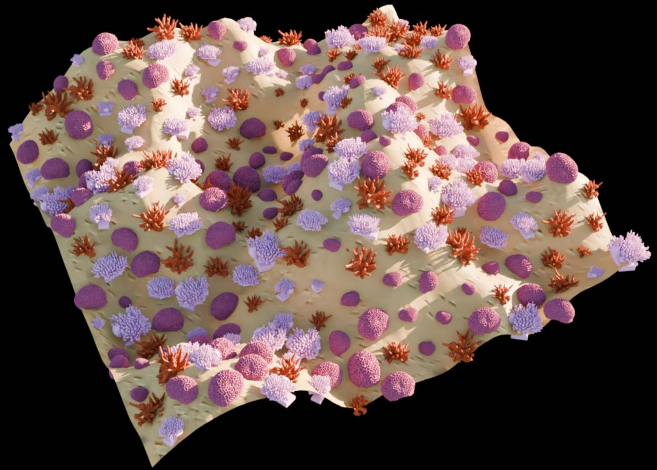


Visible structural aspects





Research Question(s) > Their answers > Limitations > Q&A



- ***What*** data sources are relevant?
- ***How*** to process and extract information?
- ***How*** to turn *that* into modelling?
- ***What*** can we achieve for automated modelling?
  / overall conclusion

Limitations + Future work

Q&A

- ***What*** **data sources are relevant?**
- ***How*** to process and extract information?
- ***How*** to turn *that* into modelling?
- ***What*** can we achieve for automated modelling?

- 3D data
- Segmented Images
- CoralNet (images)
- GBIF (observations)
- Allen Coral Atlas (zones)
- Smithsonian Institution's 3D model collection
- Coral Traits Database

Smithsonian Institution

Acropora cervicornis

Acropora prolifera

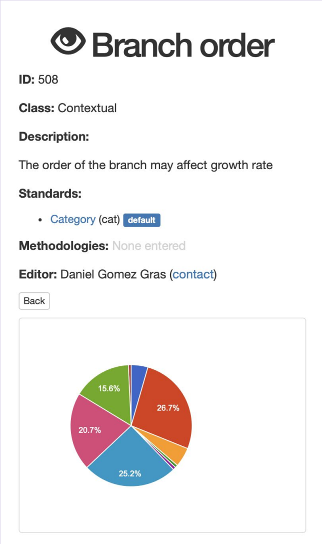
Acropora valenciennesi

Heliopora coerulea

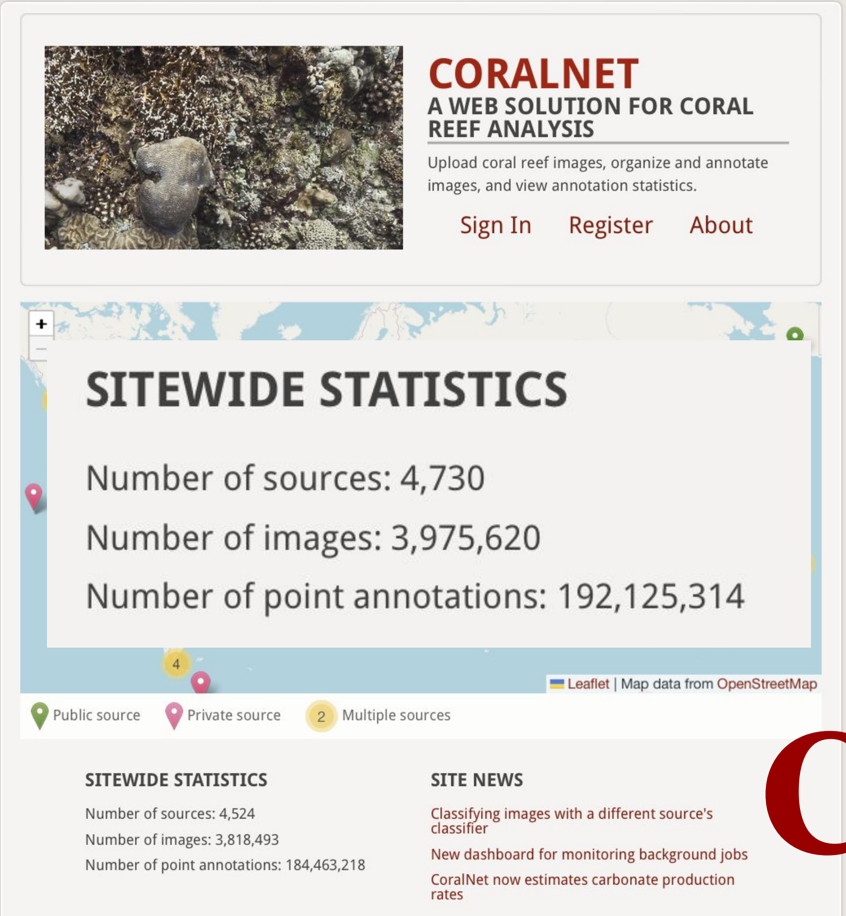
Goniastrea favulus

Corallium sp.

3D Data

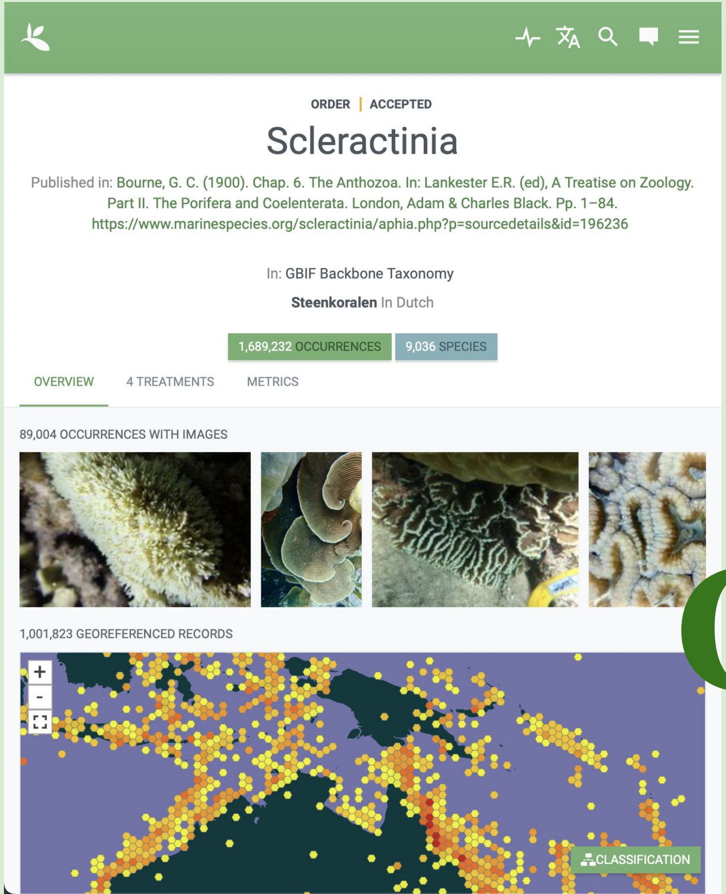


Coral Trait Database


CORALNET
A WEB SOLUTION FOR CORAL REEF ANALYSIS
Upload coral reef images, organize and annotate images, and view annotation statistics.
Sign In
Register
About
SITEWIDE STATISTICS
Number of sources: 4,730
Number of images: 3,975,620
Number of point annotations: 192,125,314
4
Leaflet | Map data from OpenStreetMap
Public source
Private source
2
Multiple sources
SITEWIDE STATISTICS
Number of sources: 4,524
Number of images: 3,818,493
Number of point annotations: 184,463,218
SITE NEWS
Classifying images with a different source's classifier
New dashboard for monitoring background jobs
CoralNet now estimates carbonate production rates


??
Acropora cerv.
Helioseris cucullata

CoralNet

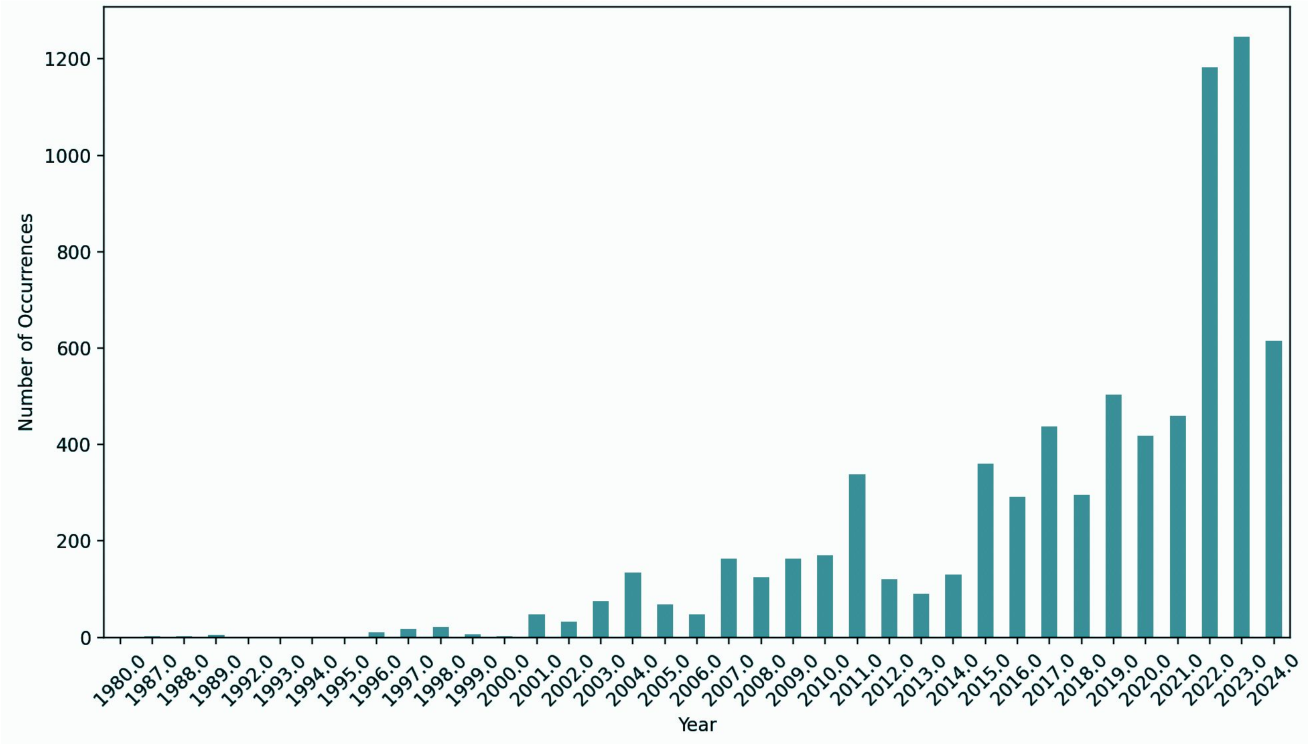


- \+ Quantity
- \+ Taxonomy
- \- Coordinate Errors
- \- Spatial Bias

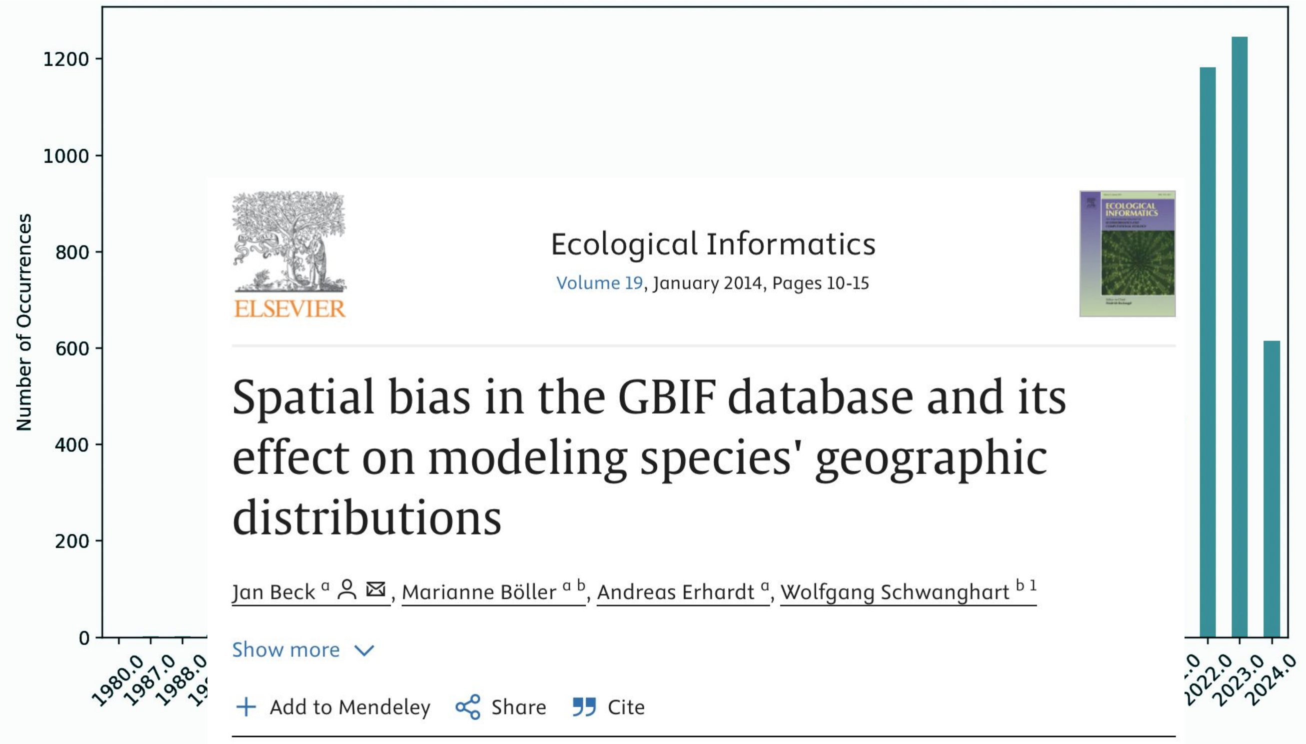
GBIF

Global Biodiversity Information Facility

GBIFs (coral) occurrences per year



GBIFs (coral) occurrences per year



Ecological Informatics
Volume 19, January 2014, Pages 10-15

Spatial bias in the GBIF database and its effect on modeling species' geographic distributions

Jan Beck [a], Marianne Böller [a b], Andreas Erhardt [a], Wolfgang Schwanghart [b 1]

Show more

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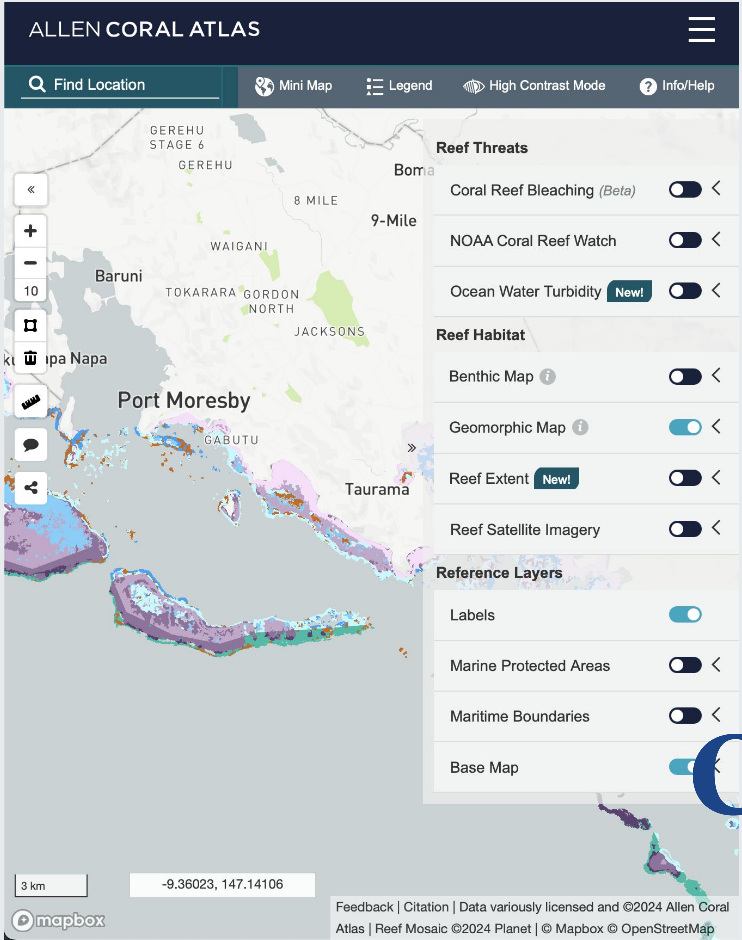
https://doi.org/10.1016/j.ecoinf.2013.11.002



+ Coverage

+ Classification System

- No indv. corals

Allen Coral Atlas

- ***What*** data sources are relevant?
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- *What* data sources are relevant?
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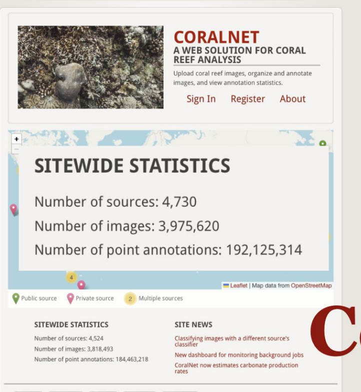
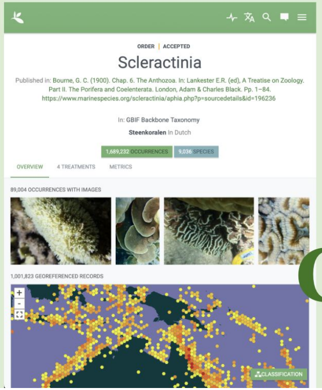


CoralNet



GBIF

Global Biodiversity Information Facility

+ Quantity
+ Taxonomy
- Coordinate Errors
- Spatial Bias

8.167 images with "zebra" & "giraffe"

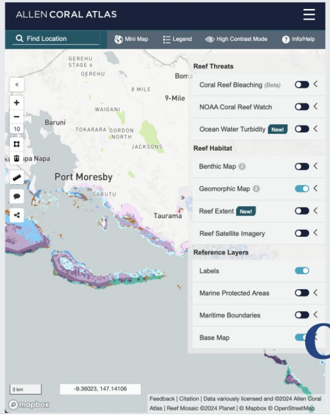
0 images with "zebra" & "polar bear"

▻ zebras & polar bears never co-occur

9.893 zebra observations

21 polar bear observations

▻ zebras occur (way) more often in Area A

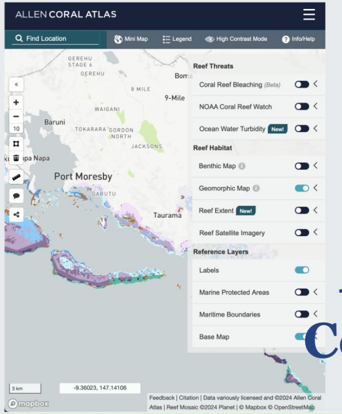


Allen
Coral Atlas

+ Coverage
+ Classification System
- No indv. corals

12.000 km2 "savanna" ▻ zebras?

1.600 km2 "arctic" ▻ polar bears?



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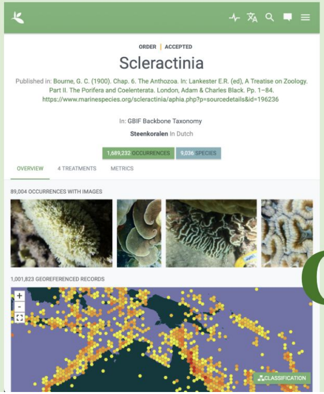


GBIF
Global Biodiversity Information Facility

+ Quantity
+ Taxonomy
- Coordinate Errors
- Spatial Bias

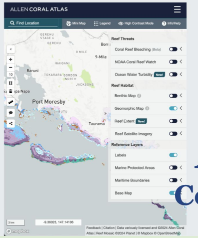
9.893 zebra observations

21 polar bear observations

▻ zebras occupy 20% of savanna

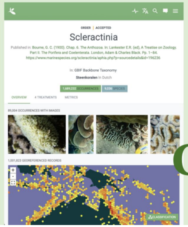
▻ zebras occupy 0% of arctic

Large



+ Coverage
+ Classification System
- No indv. corals

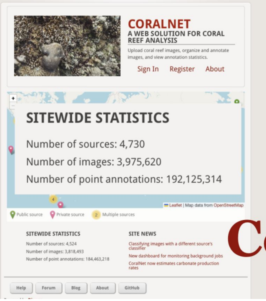
Allen
Coral Atlas



+ Quantity
+ Taxonomy
- Coordinate Errors
- Spatial Bias

GBIF
Global Biodiversity Information Facility

Medium



CoralNet

Small

Coral Reefs (2017) 36:1291–1305
DOI 10.1007/s00338-017-1624-3

CrossMark

REPORT

Large-area imaging reveals biologically driven non-random spatial patterns of corals at a remote reef

Clinton B. Edwards[1] · Yoan Eynaud[1] · Gareth J. Williams[1,2] · Nicole E. Pedersen[1] · Brian J. Zgliczynski[1] · Arthur C. R. Gleason[3] · Jennifer E. Smith[1] · Stuart A. Sandin[1]

Received: 9 May 2016 / Accepted: 14 September 2017 / Published online: 12 October 2017
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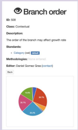
Abstract For sessile organisms such as reef-building corals, differences in the degree of dispersion of individuals across a landscape may result from important differences in life-history strategies or may reflect patterns of habitat availability. Descriptions of spatial patterns can thus be useful not only for the identification of key biological and physical mechanisms structuring an ecosystem, but also by providing the data necessary to generate and test ecological theory. Here, we used an in situ imaging technique to create large-area photomosaics of 16 plots at Palmyra Atoll, central Pacific, each covering 100 m^2 of benthic habitat. We mapped the location of 44,008 coral colonies and identified each to the lowest taxonomic level possible. Using metrics of spatial dispersion, we tested for clustered and the degree of clustering varied by taxon. A small number of taxa did not significantly depart from randomness and none revealed evidence of spatial uniformity. Importantly, taxa that readily fragment or tolerate stress through partial mortality were more clustered. With little exception, clustering patterns were consistent with models of fragmentation and dispersal limitation. In some taxa, dispersion was linearly related to abundance, suggesting density dependence of spatial patterning. The spatial patterns of stony corals are non-random and reflect fundamental life-history characteristics of the taxa, suggesting that the reef landscape may, in many cases, have important elements of spatial predictability.

3D Data

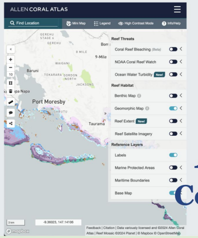


Coral Trait Database

Large

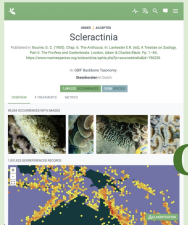
Medium

Small



+ Coverage
+ Classification System
- No indv. corals

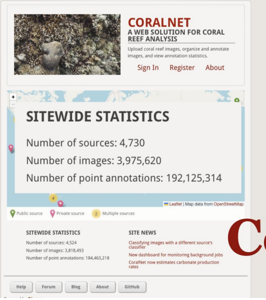
Allen Coral Atlas



+ Quantity
+ Taxonomy
- Coordinate Errors
- Spatial Bias

GBIF

Global Biodiversity Information Facility



CoralNet

91 co-occurrences

21 species combinations

6 single occ. species comb.

Coral Reefs (2017) 36:1291–1305
DOI 10.1007/s00338-017-1624-3

REPORT

Large-area imaging reveals biologically driven non-random spatial patterns of corals at a remote reef

Clinton B. Edwards[1] · Yoan Eynaud[1] · Gareth J. Williams[1,2] · Nicole E. Pedersen[1] · Brian J. Zgliczynski[1] · Arthur C. R. Gleason[3] · Jennifer E. Smith[1] · Stuart A. Sandin[1]

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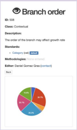
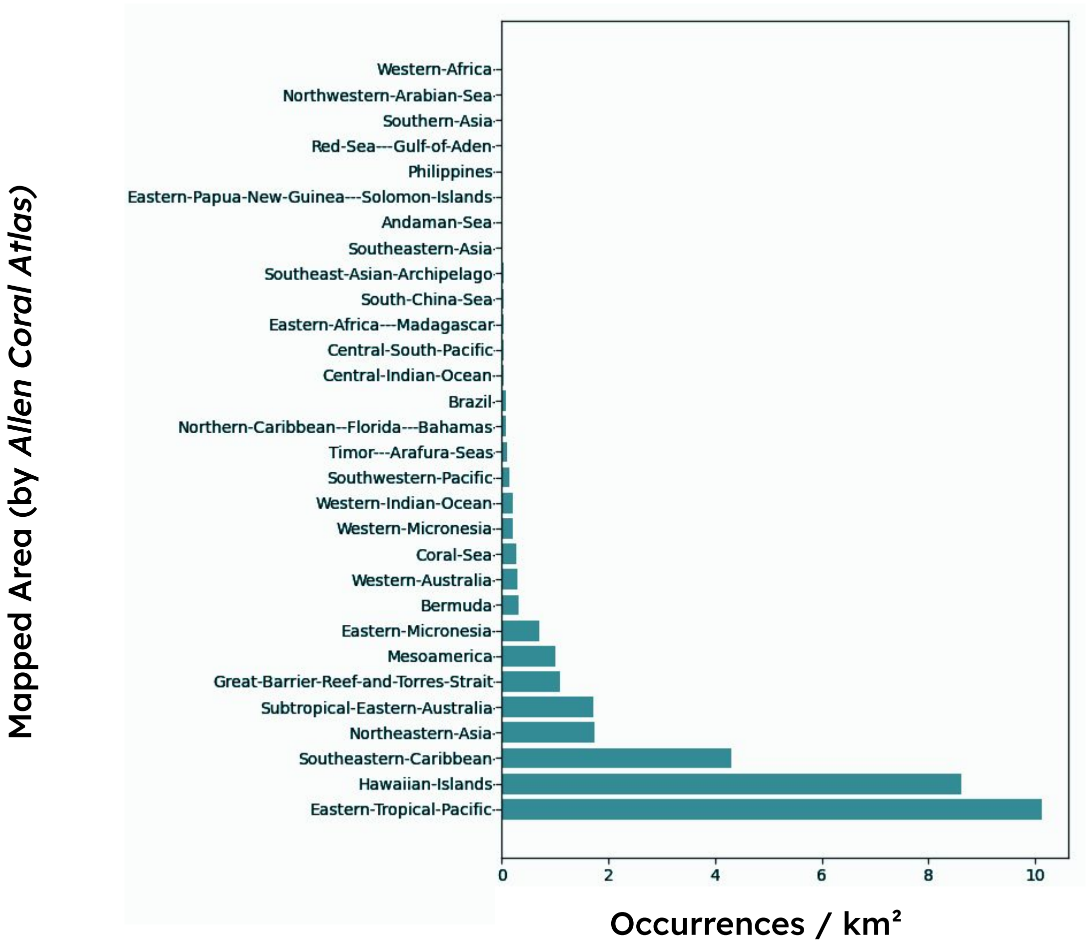


Coral Trait Database


Mapped Area (by Allen Coral Atlas)
Western-Africa
Northwestern-Arabian-Sea
Southern-Asia
Red-Sea---Gulf-of-Aden
Philippines
Eastern-Papua-New-Guinea---Solomon-Islands
Andaman-Sea
Southeastern-Asia
Southeast-Asian-Archipelago
South-China-Sea
Eastern-Africa---Madagascar
Central-South-Pacific
Central-Indian-Ocean
Brazil
Northern-Caribbean--Florida---Bahamas
Timor---Arafura-Seas
Southwestern-Pacific
Western-Indian-Ocean
Western-Micronesia
Coral-Sea
Western-Australia
Bermuda
Eastern-Micronesia
Mesoamerica
Great-Barrier-Reef-and-Torres-Strait
Subtropical-Eastern-Australia
Northeastern-Asia
Southeastern-Caribbean
Hawaiian-Islands
Eastern-Tropical-Pacific
0
2
4
6
8
10
Occurrences / km²

- ▻ ***What*** data sources are relevant?
- ▻ ***How*** to process and extract information?
- ▻ ***How*** to turn ***that*** into modelling?
- ▻ ***What*** can we achieve for automated modelling?

- ▻ 3D data
- ▻ Segmented Images
- ▻ CoralNet (images)
- ▻ GBIF
- ▻ Allen Coral Atlas
- ▻ Smithsonian Institution's 3D model collection
- ▻ Coral Traits Database

Synonyms

Acropora cervicornis (Lamarck, 1816)

- ✗ *Madrepora cervicornis* Lamarck, 1816
- ✗ *Acropora muricata var. cervicornis* (Lamarck, 1816)
- ✗ *Madrepora attenuata* Brook, 1893
- ✗ *Acropora attenuata* (Brook, 1893)

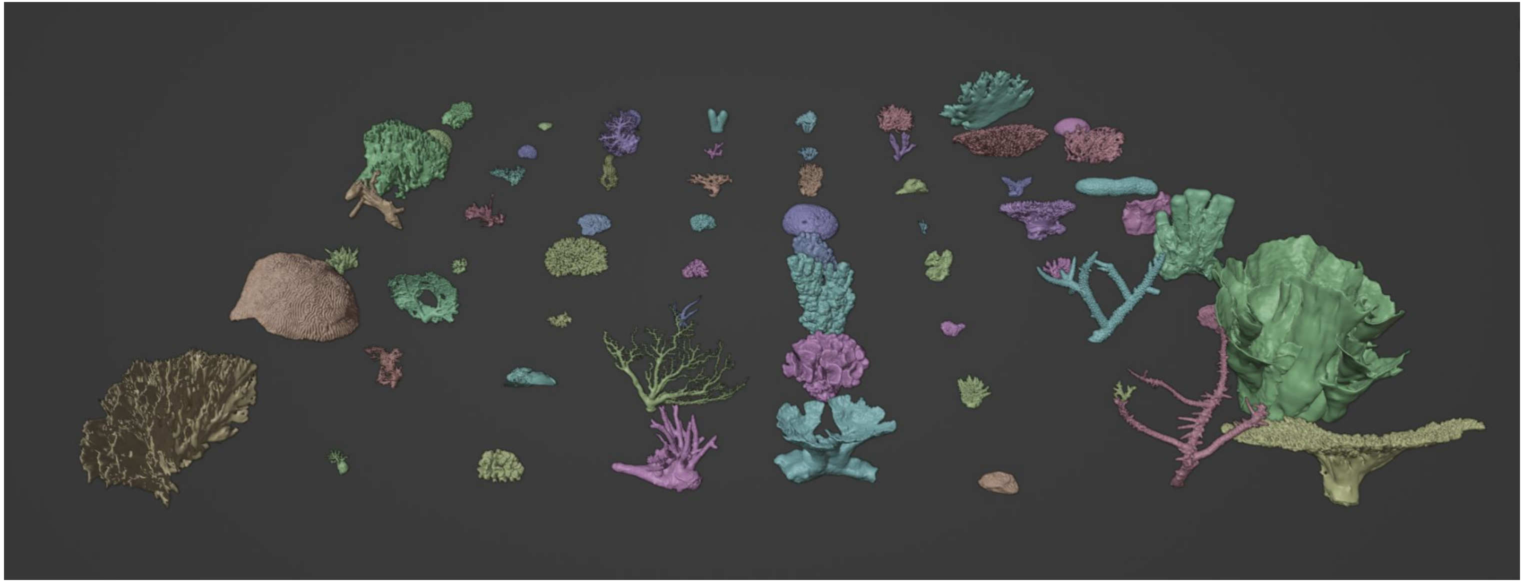
Synonyms

Acropora cervicornis (Lamarck, 1816)

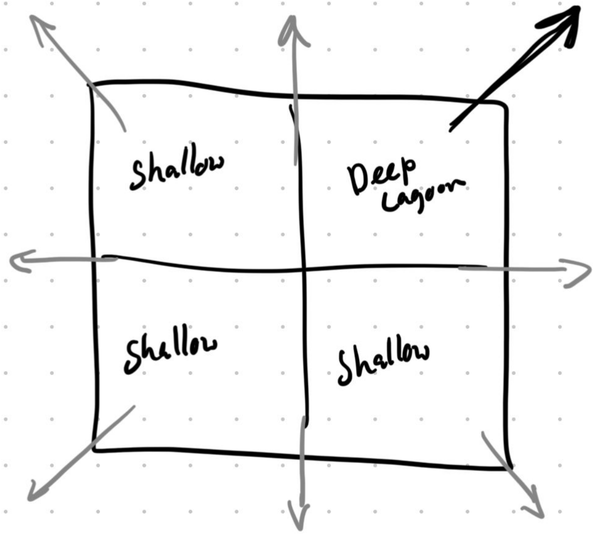
WoRMS
World Register of Marine Species

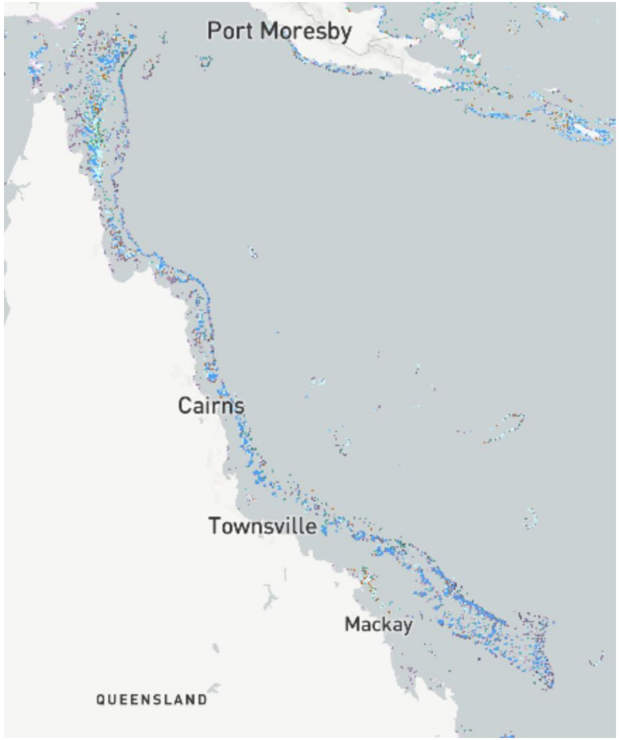
Broch, 1936", "Porites sanctithomae Bernard, 1906", "*Madrepora cervicornis* Lamarck, 1816", *"Astraea (Fissicella) favulus*

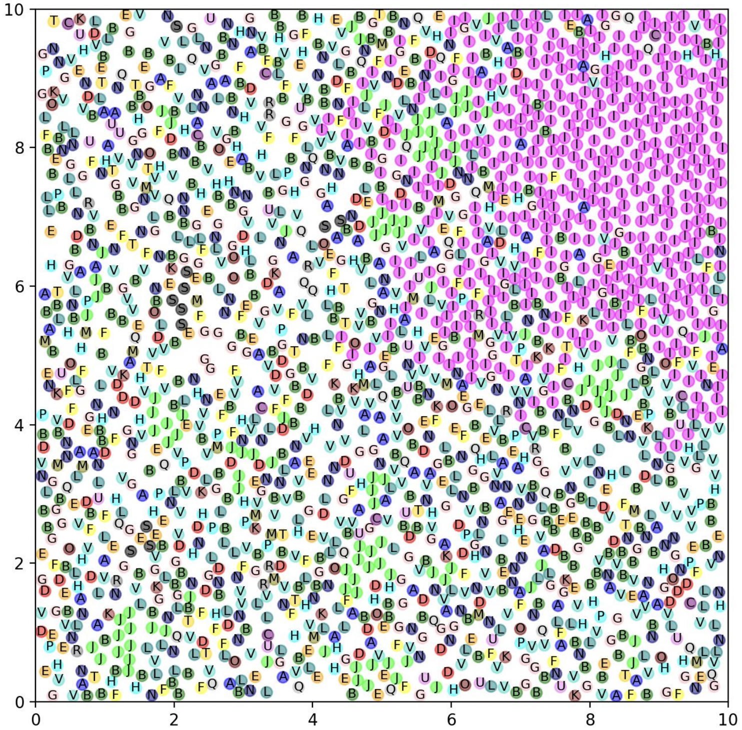
3D Model Collection



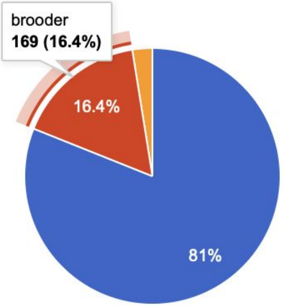
Zone Analysis







Mode of larval development

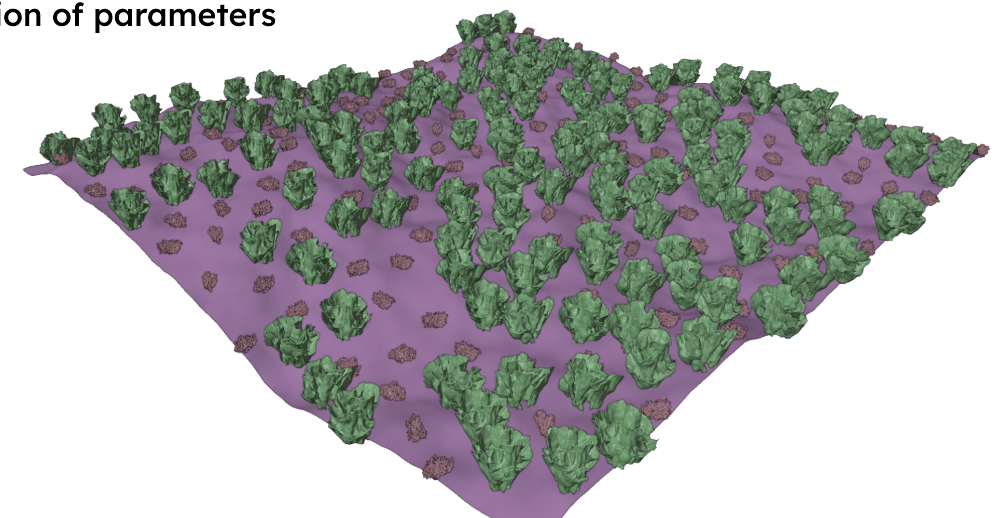


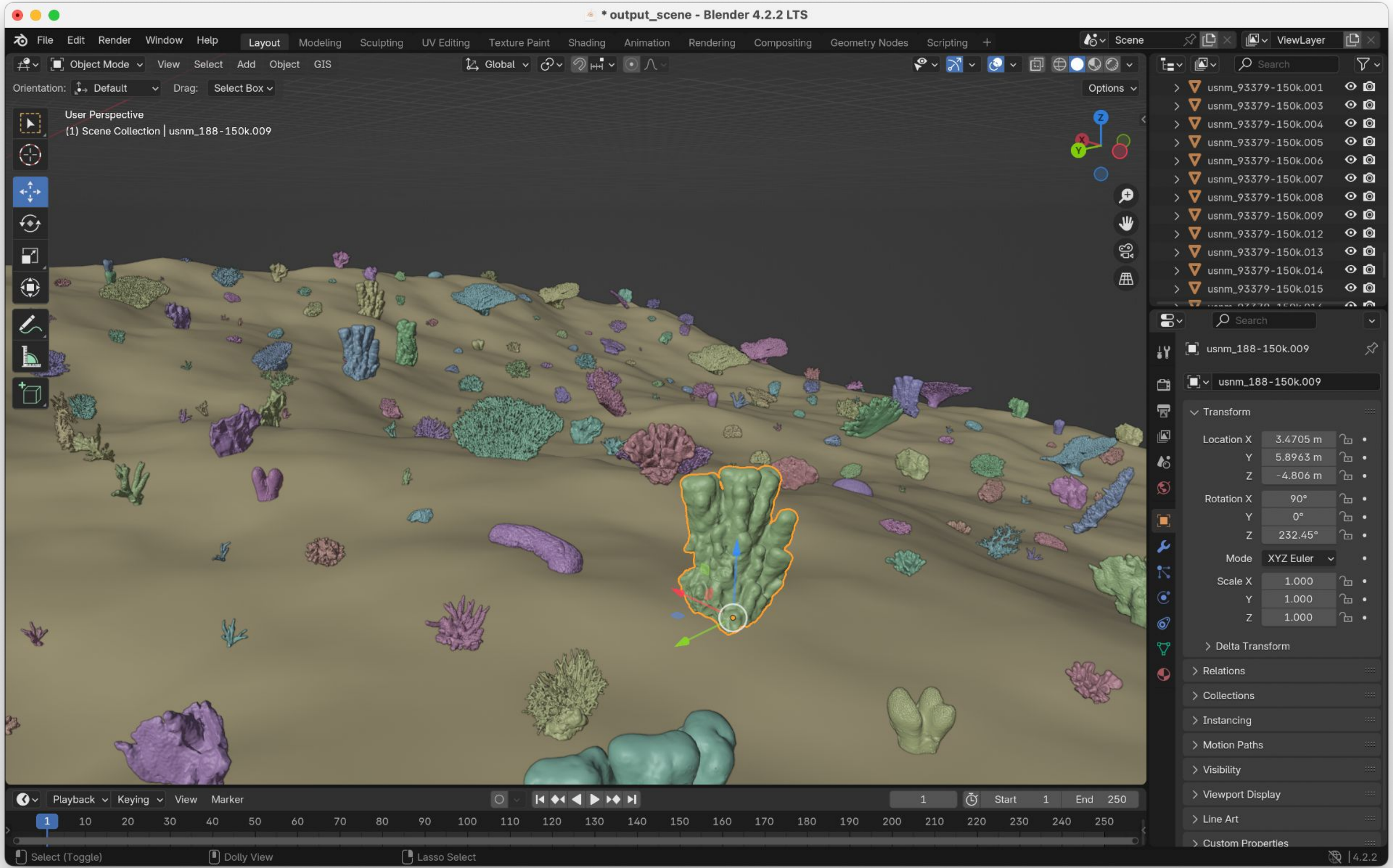
- *What* data sources are relevant?
- *How* to process and extract information?
- *How* to turn *that* into modelling?
- ***What* can we achieve for automated modelling?**

- 3D data
- Segmented Images
- CoralNet (images)
- GBIF
- Allen Coral Atlas
- Smithsonian Institution's 3D model collection
- Coral Traits Database

Limitations of the Pipeline

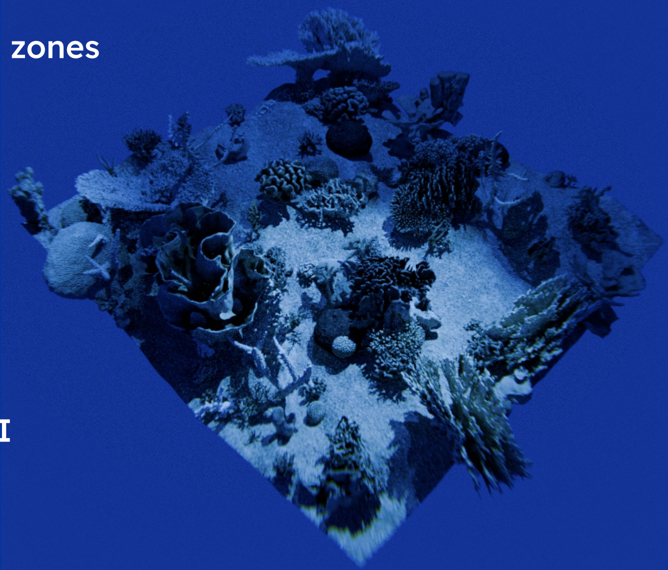
- "building-blocks": no structural variation
- "density": could not be extracted, manual parameter
- ***Terrain generation*** relies on manual configuration of parameters
- The models are 2D + 2.5D + 3D
- What species … ?




* output_scene - Blender 4.2.2 LTS
File
Edit
Render
Window
Help
Layout
Modeling
Sculpting
UV Editing
Texture Paint
Shading
Animation
Rendering
Compositing
Geometry Nodes
Scripting
Scene
ViewLayer
Object Mode
View
Select
Add
Object
GIS
Global
Orientation:
Default
Drag:
Select Box
Options
User Perspective
(1) Scene Collection | usnm_188-150k.009
usnm_93379-150k.001
usnm_93379-150k.003
usnm_93379-150k.004
usnm_93379-150k.005
usnm_93379-150k.006
usnm_93379-150k.007
usnm_93379-150k.008
usnm_93379-150k.009
usnm_93379-150k.012
usnm_93379-150k.013
usnm_93379-150k.014
usnm_93379-150k.015
Search
usnm_188-150k.009
usnm_188-150k.009
Transform
Location X
3.4705 m
Y
5.8963 m
Z
-4.806 m
Rotation X
90°
Y
0°
Z
232.45°
Mode
XYZ Euler
Scale X
1.000
Y
1.000
Z
1.000
Delta Transform
Relations
Collections
Instancing
Motion Paths
Visibility
Viewport Display
Line Art
Custom Properties
Playback
Keying
View
Marker
1
Start
1
End
250
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Select (Toggle)
Dolly View
Lasso Select
4.2.2

Conclusions & Future Work
Contributions

- Combined Allen Coral Atlas with GBIFs occurrence data
- Analyzed directional patterns in Allen Coral Atlas' geomorphic zones
- Revealed (severe) spatial bias in GBIFs data for corals
- Failed experiments: CoralNet, Image + AI
- Natural clustering algorithm
- Solution for ensuring taxonomic compatibility
- Taxonomic assessments for GBIF, CoralNet, Coral Traits DB, SI
- Laid foundation for modelling pipeline

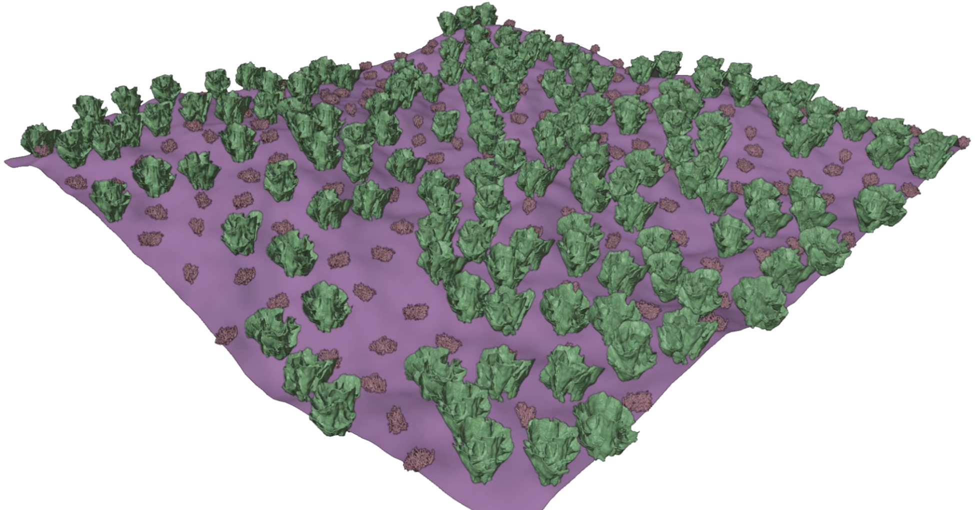


Limitations of Research

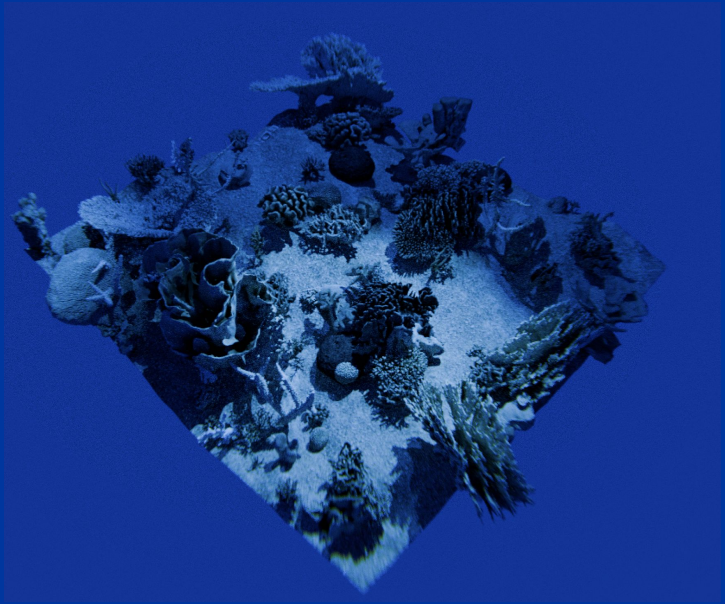
- Analysis done with 51 species
- Choice for Geomorphic zones
- Terrain features
- Clustering *behaviour*?

"What can be achieved *now*?"

"How to lay a *foundation*?"



Q&A



PLOS ONE

RESEARCH ARTICLE

Automated classification of three-dimensional reconstructions of coral reefs using convolutional neural networks

Brian M. Hopkinson[1]*, **Andrew C. King**[2], **Daniel P. Owen**[1], **Matthew Johnson-Roberson**[3], **Matthew H. Long**[4], **Suchendra M. Bhandarkar**[2,5]

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* bmhopkin@uga.edu

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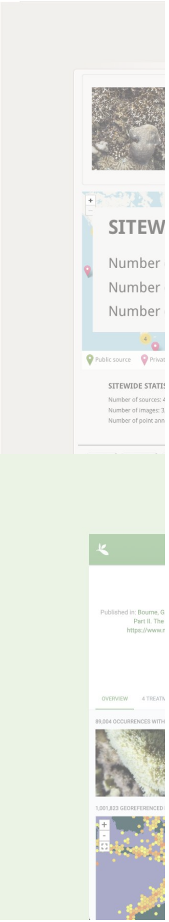
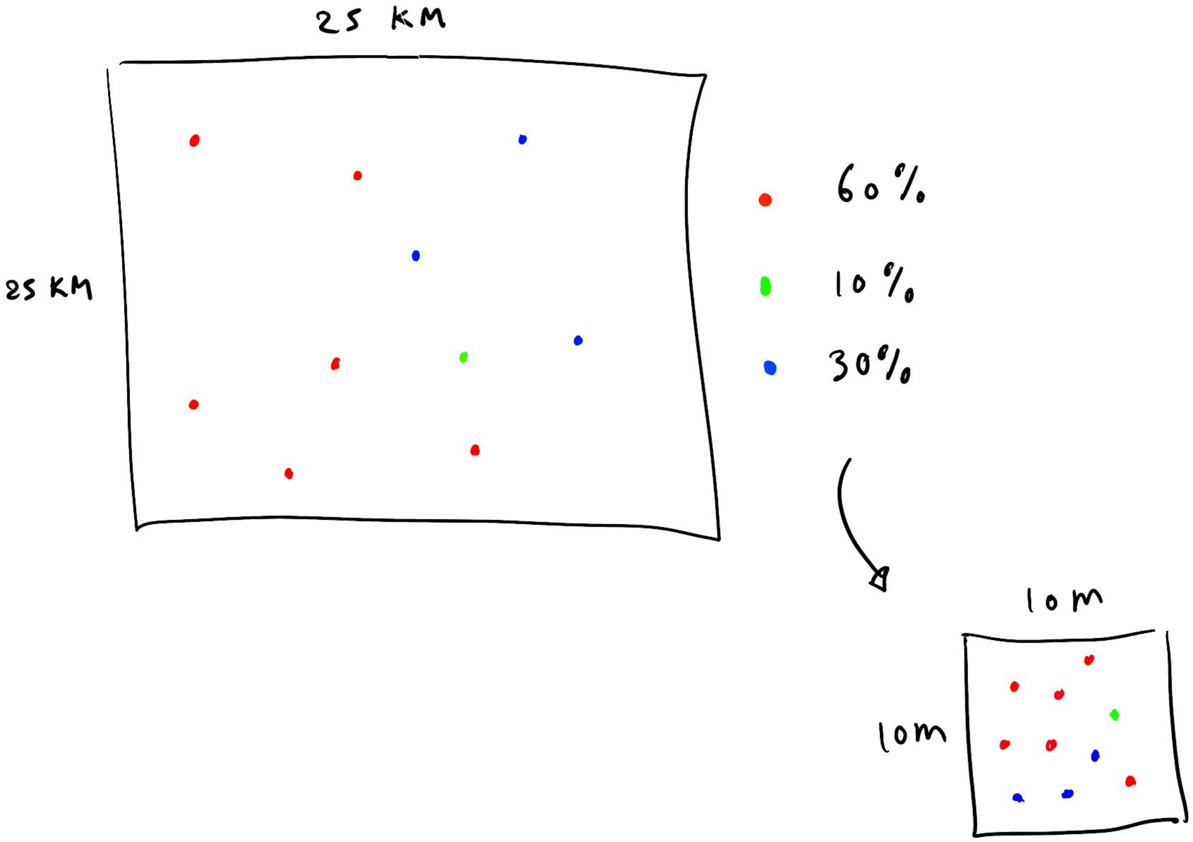
Abstract

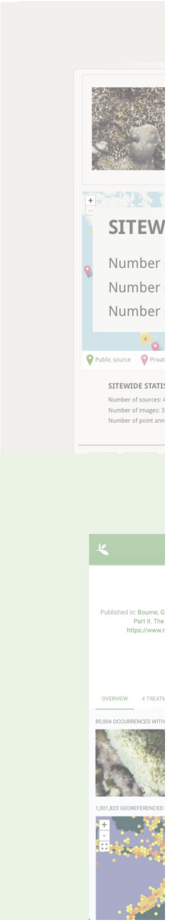
Coral reefs are biologically diverse and structurally complex ecosystems, which have been severally affected by human actions. Consequently, there is a need for rapid ecological assessment of coral reefs, but current approaches require time consuming manual analysis, either during a dive survey or on images collected during a survey. Reef structural complexity is essential for ecological function but is challenging to measure and often relegated to simple metrics such as rugosity. Recent advances in computer vision and machine learning offer the potential to alleviate some of these limitations. We developed an approach to automatically classify 3D reconstructions of reef sections and assessed the accuracy of this approach. 3D reconstructions of reef sections were generated using commercial Structure-from-Motion software with images extracted from video surveys. To generate a 3D classified map, locations on the 3D reconstruction were mapped back into the original images to extract multiple views of the location. Several approaches were tested to merge information from multiple views of a point into a single classification, all of which used convolutional neu-

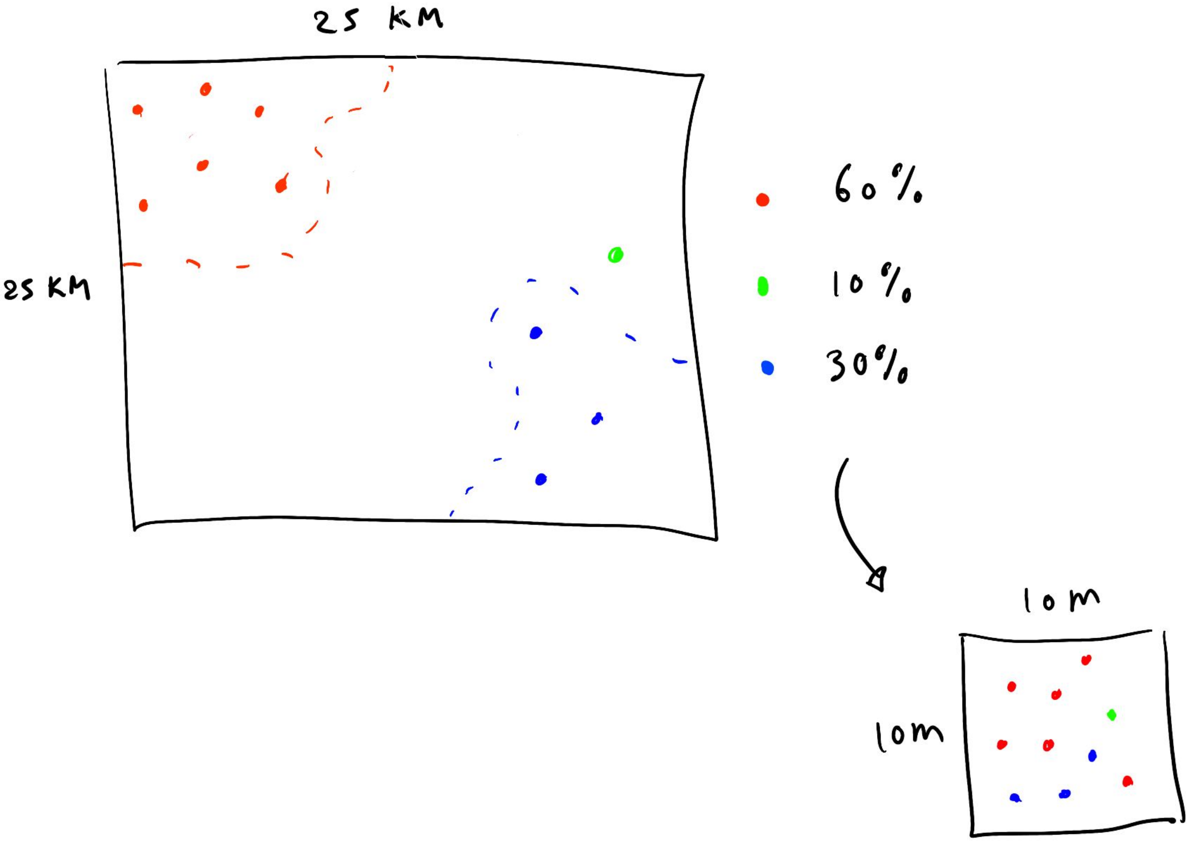




ffe"
ar bear"
ccur

Area A





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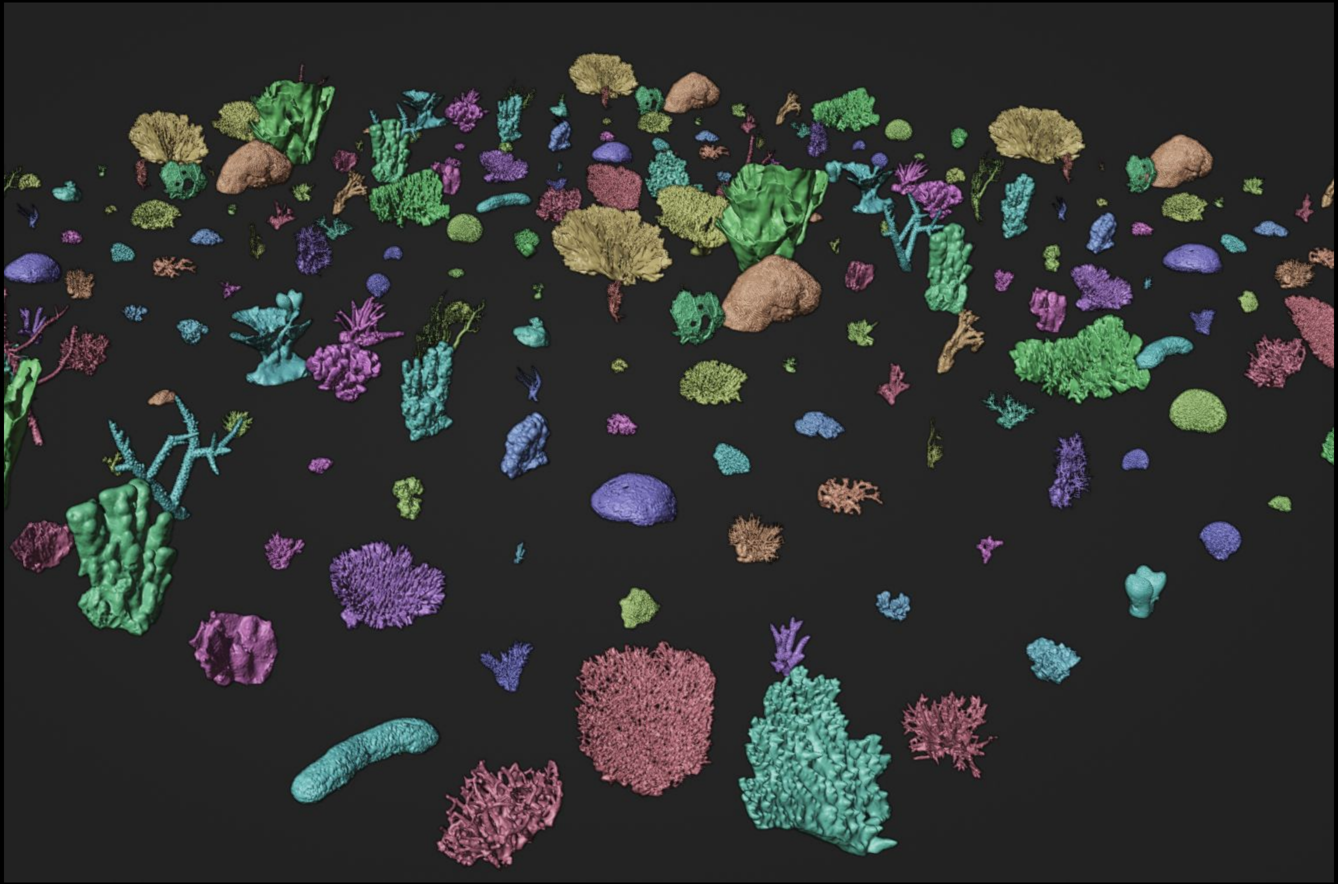
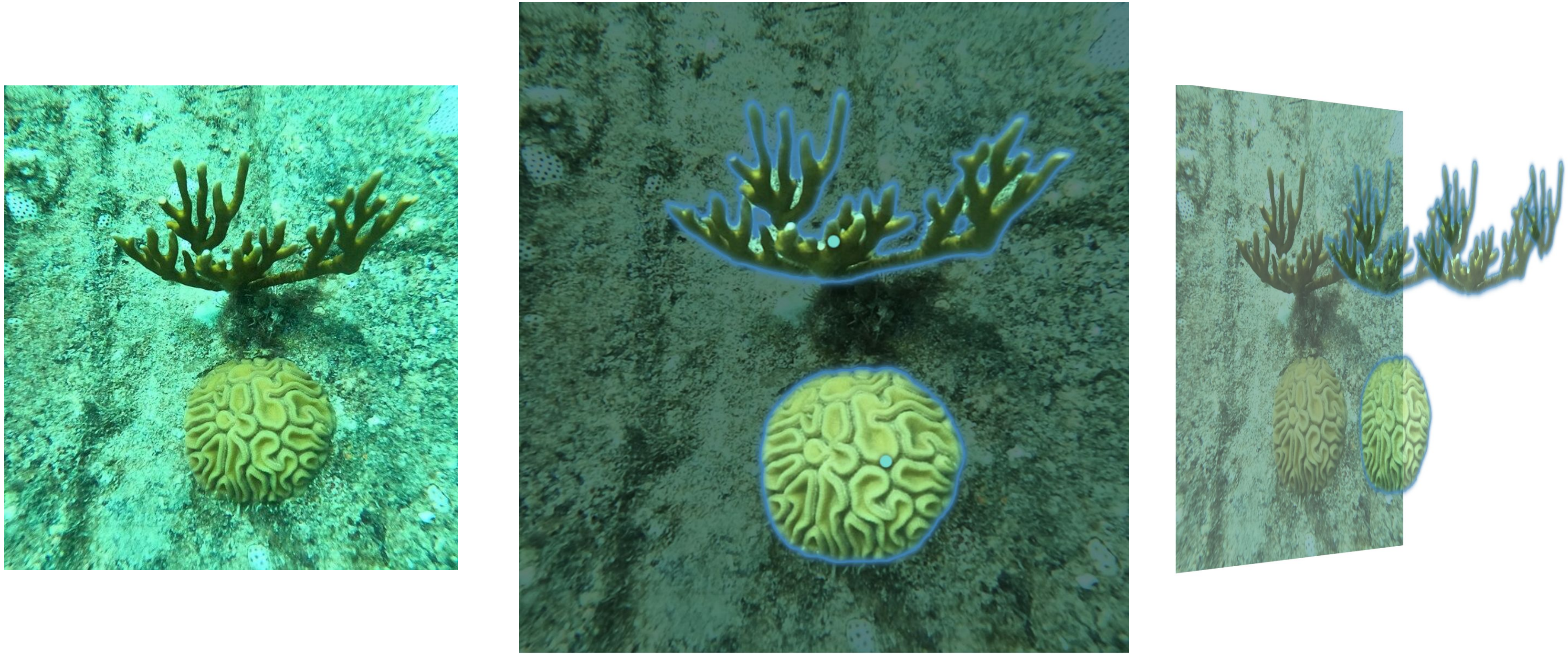
ar bear"

ccur

Area A





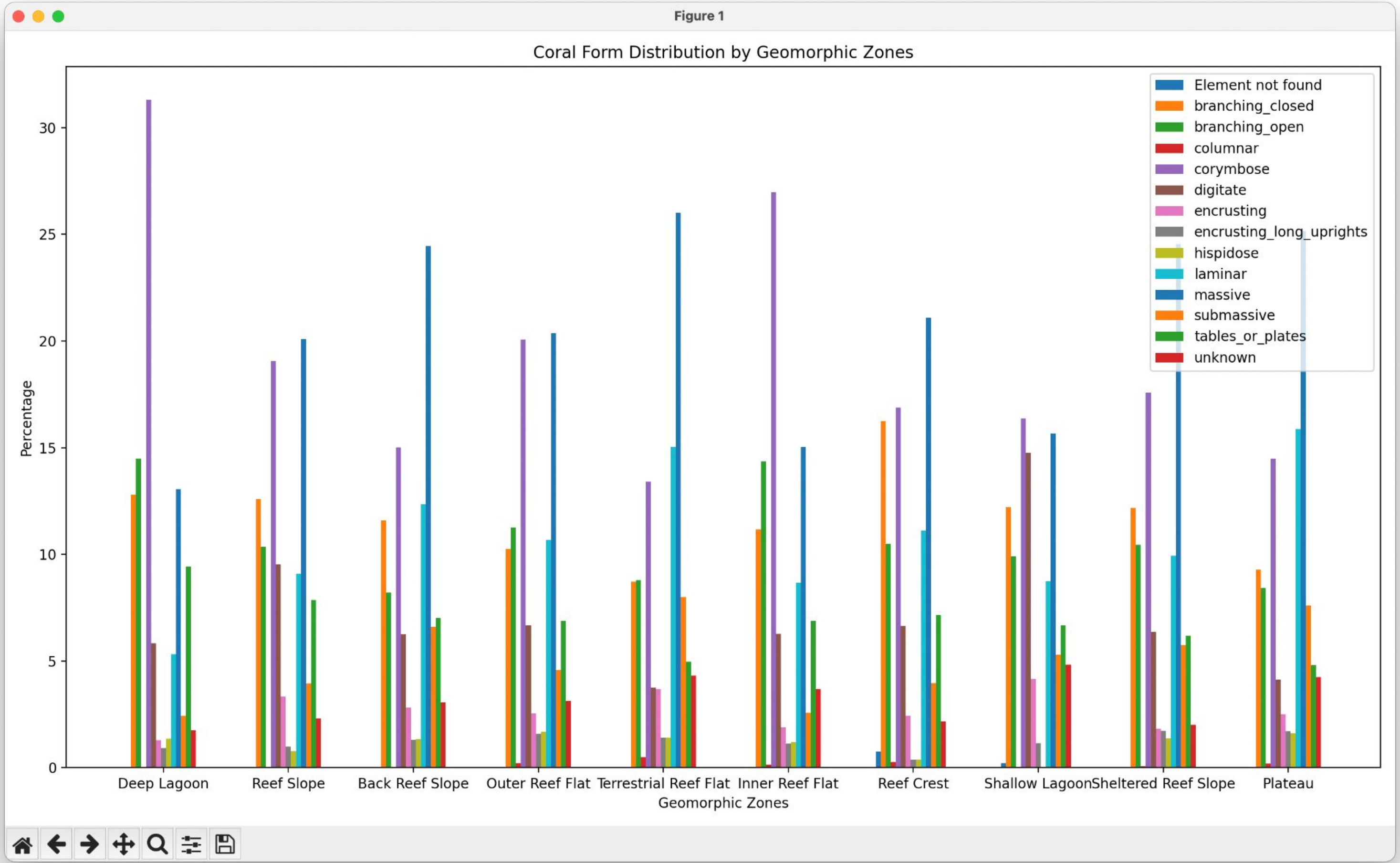
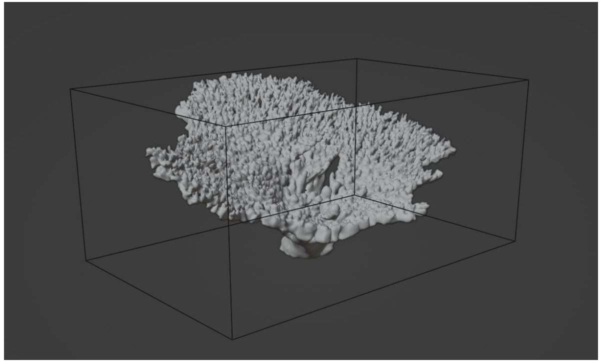
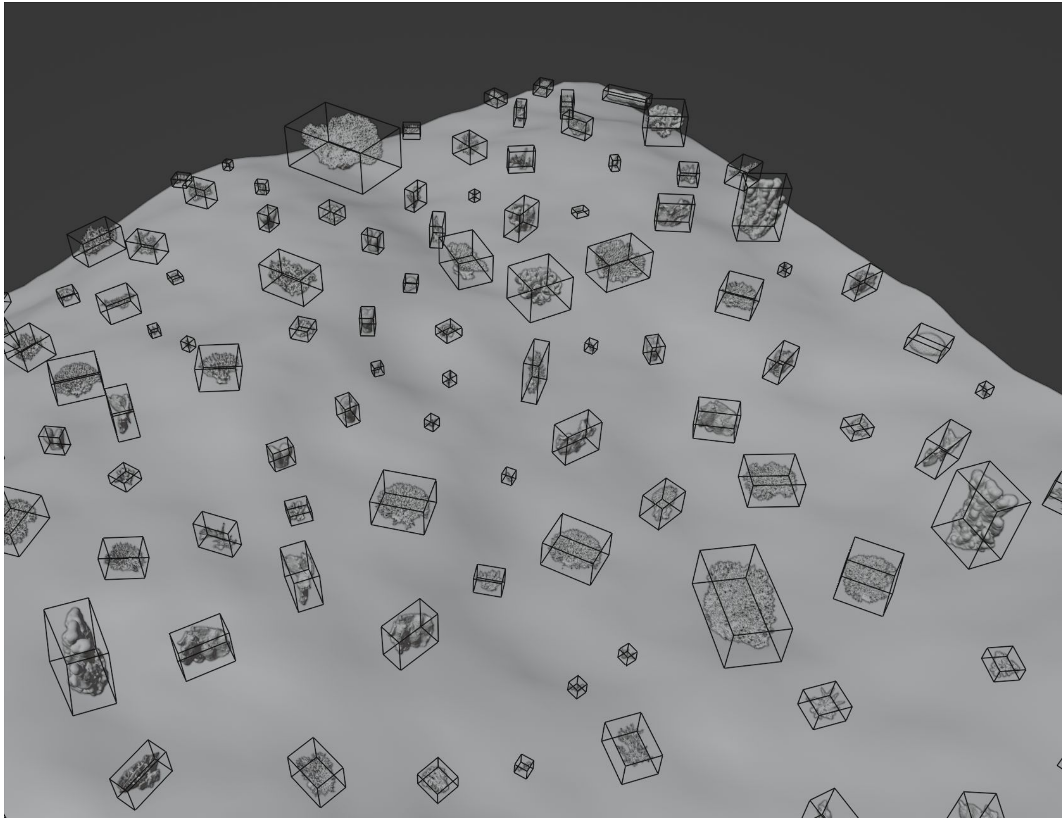
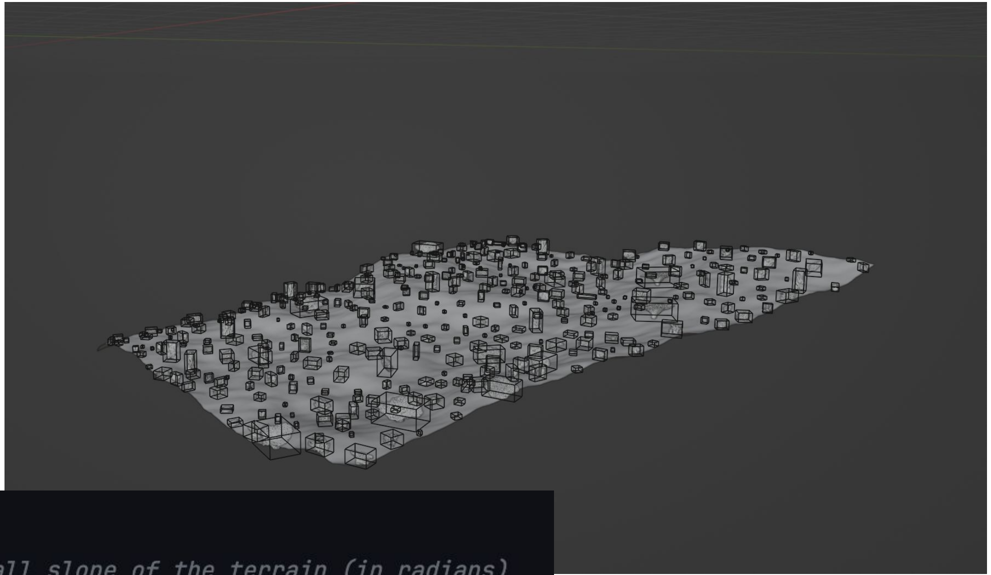


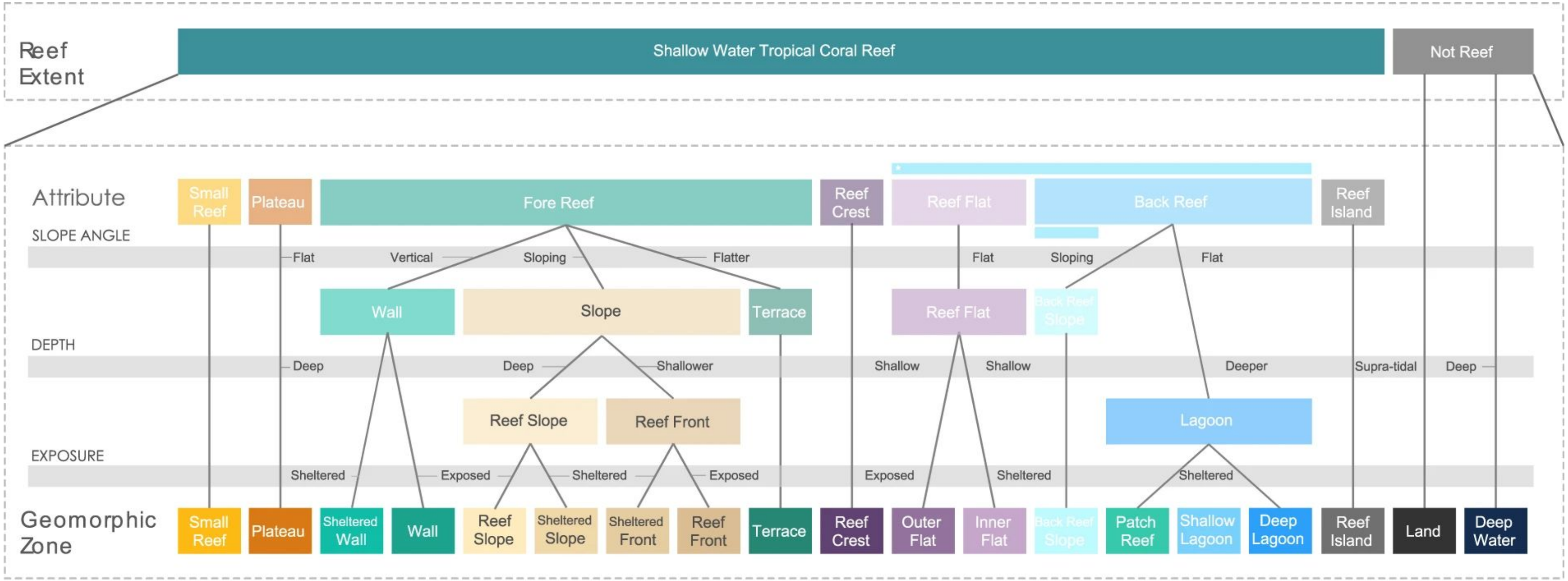
Figure 1
Coral Form Distribution by Geomorphic Zones
Percentage
0
5
10
15
20
25
30
Deep Lagoon
Reef Slope
Back Reef Slope
Outer Reef Flat
Terrestrial Reef Flat
Inner Reef Flat
Reef Crest
Shallow Lagoon
Sheltered Reef Slope
Plateau
Geomorphic Zones
Element not found
branching_closed
branching_open
columnar
corymbose
digitate
encrusting
encrusting_long_uprights
hispidose
laminar
massive
submassive
tables_or_plates
unknown



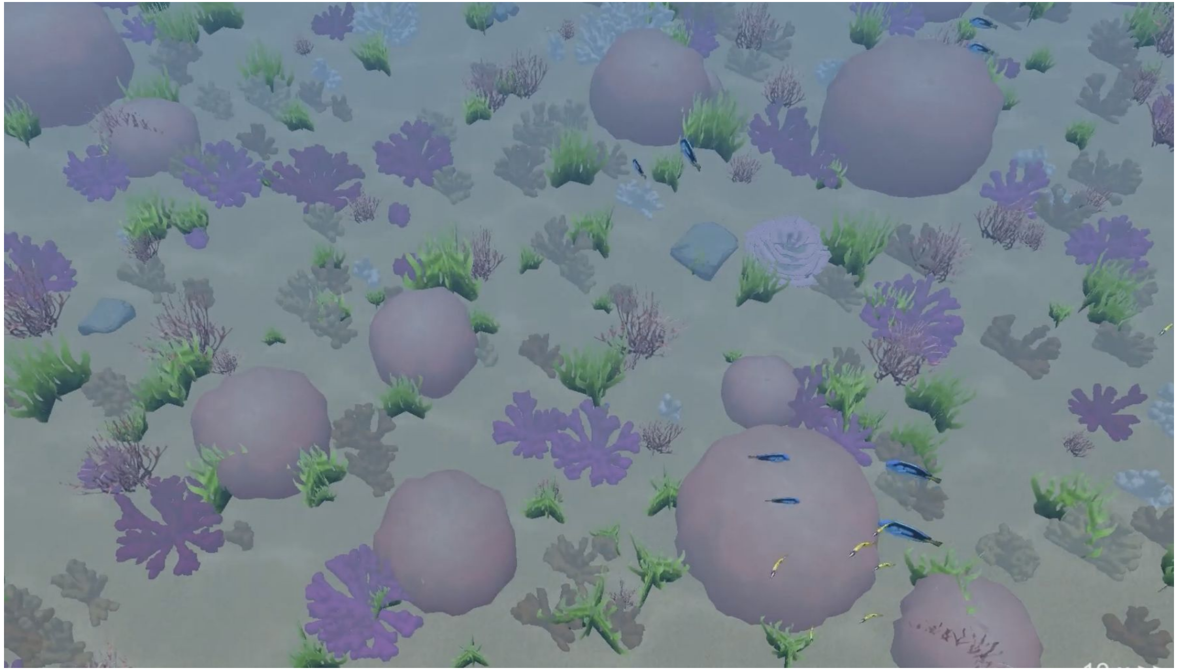




```
# PARAMETERS FOR TERRAIN GENERATION (fBm)
overall_slope = math.radians(30)      # Overall slope of the terrain (in radians)
overall_aspect = math.radians(45)  # Overall aspect of the terrain (in radians)
depth = 5.0              # (Water) depth of the terrains center
```



*BACK REEF (alternative definitions)



https://www.youtube.com/watch?v=kSLKv7TnjSg

Automated 3D Classification

Transferability
Resolution (no fine details)
Texture-based
Few taxa

CoralVOS classification

Transferability?
Few taxa